

THE PLAIN X-RAY IN THE ACUTE ABDOMEN

P. W. R. LEE, M.B., Ch.B., F.R.C.S.E., F.R.C.S.

SUBMITTED FOR THE DEGREE OF DOCTOR OF MEDICINE
UNIVERSITY OF EDINBURGH

1977



ABSTRACT OF THESIS

Name of Candidate ...P. W. R. LEE.....
Address ...UNIVERSITY DEPARTMENT OF SURGERY, THE GENERAL INFIRMARY AT LEEDS.....
DegreeM.D..... Date7/5/77.....
Title of Thesis ...THE PLAIN X-RAY IN THE ACUTE ABDOMEN.....

A quantitative study of the plain x-ray in the acute abdomen, written from the point of view of the surgeon rather than the radiologist, is presented. Three questions are asked:

1. Which radiological signs are present in the plain x-ray in the acute abdomen and with what incidence?
2. Should plain x-rays be routinely performed in the acute abdomen?
3. Who should report the acute abdominal x-ray?

All patients entered into the study were managed personally by the author. In the first part of the thesis, the plain abdominal x-rays of a series of patients (277 in all) suffering from each of the five most common acute abdominal diseases were reviewed for specific radiological features to assess the relative incidence and importance of each sign. In the second part of the thesis 249 consecutive patients admitted to hospital with an acute abdomen due to all types of disease were studied, and the plain abdominal x-rays of each assessed for their value in diagnosis. In the third part of the thesis, a questionnaire of 50 plain abdominal x-rays was answered by surgeons and radiologists of varying clinical experience and the scores of each group compared.

continued ..

The results of the study showed that:

1. Specific radiological features were found in not less than 48% of the x-rays of the five acute abdominal diseases studied in detail.
2. When performed routinely, 'positive' help was obtained from the acute abdominal x-rays of 42% of the 249 patients studied. An argument is presented for the inclusion of the plain x-ray as a routine in the acute abdomen.
3. The plain abdominal x-rays should be reported by a senior radiologist at the time of the investigation, if maximum benefit to both patient and surgeon is to be obtained.

VOLUME I

CONTENTS

	<u>Page</u>
<u>Introduction</u>	2
<u>Part I</u> <u>Which radiological signs occur in the plain x-ray</u> <u>of the Acute Abdomen and with what incidence?</u>	5
Chapter 1 Acute Appendicitis	7
Chapter 2 Acute Cholecystitis	18
Chapter 3 Acute Pancreatitis	28
Chapter 4 Pneumoperitoneum	39
Chapter 5 Intestinal Obstruction	
Part 1 Small bowel obstruction	53
Part 2 Large bowel obstruction	74
<u>Part II</u> <u>Should plain abdominal x-rays be performed</u> <u>routinely in the Acute Abdomen?</u>	91
<u>Part III</u> <u>Who should report the Acute Abdominal x-ray?</u>	122
<u>Conclusion</u>	127
<u>Bibliography</u>	
<u>Acknowledgements</u>	
<u>Appendix I</u> - Questionnaire	
<u>Appendix II</u> - Publications	
<u>Figures</u> - Volume II	

Introduction

My belly hurts the patient cried
When I move from side to side
All the food that I sup
Is straight away brought back up
Can X-ray tell what's wrong inside?

(Zachary Cope - amended)

The plain X-ray in the acute abdomen is a subject about which much has been written in the radiological journals; most surgeons, however, would readily admit that they are unfamiliar with the details of this literature. In spite of this, it has become accepted in this country that it is the surgeon who assesses his own X-rays on the emergency days, and it is usually the next day, if at all, before a formal radiology report becomes available. The results presented in this dissertation represent a detailed study of the plain X-ray in the acute abdomen from a surgeon's point of view. Consideration is given not only to the incidence of specific radiological signs in the acute abdomen but also as to whether sufficient and correct use of the plain X-ray is currently being made.

The aim of the dissertation is to answer three questions:

1. Which radiological signs occur in the plain X-ray of the acute abdomen and with what incidence?

2. Should the plain abdominal X-ray be performed routinely in the acute abdomen?

and

3. Who should report the acute abdominal X-ray?

The material for the thesis has been collected over a five year period. The work was started in the Royal Infirmary at Edinburgh but the majority of the patients were seen and evaluated in the Leeds Area Group of Teaching Hospitals. This latter area is responsible for the emergency care of 750,000 people between only two major hospitals. The large amount of emergency experience afforded to the author as rotating surgical registrar and later as senior registrar has enabled the series of each aspect of the acute abdomen studied to be of an acceptable size. It should be emphasised, however, that no patient (and, therefore, no X-rays) have been included in the study unless the author has personally been involved in the management of the case. Statistical significance of the results, which can only be obtained from even larger numbers of cases has, therefore, been sacrificed for personal assessment.

As far as I am aware, the text of this thesis represents the first attempt by a single author to quantitate the value of the acute abdominal X-ray by using only those cases treated under his own care. The thesis is written from the surgeon's rather than the radiologist's point of view. It is hoped that the text, in addition to answering the specific questions asked, will offer to the surgeon a basis for his own interpretation of the

acute abdominal X-ray and because of this a broad review of the literature and full illustrations have been included.

PART I.

WHICH RADIOLOGICAL SIGNS OCCUR IN THE PLAIN
X-RAY OF THE ACUTE ABDOMEN AND WITH WHAT INCIDENCE?

Five selected acute abdominal diseases are considered:

- Chapter 1. Acute Appendicitis.
- Chapter 2. Acute Cholecystitis.
- Chapter 3. Acute Pancreatitis.
- Chapter 4. Pneumoperitonium.
- Chapter 5. Intestinal obstruction.

A list of the plain X-ray features said to occur in each of these five diseases was compiled by reviewing the available radiological literature. The incidence of these X-ray features in a series of cases, managed under the author's care as resident surgical officer, was calculated by a retrospective review of the X-rays.

CHAPTER 1ACUTE APPENDICITIS

INTRODUCTION

Acute appendicitis is the commonest condition which the emergency surgeon treats. In 1967, 59,720 patients were admitted to hospital with acute appendicitis (Hospital In-patient Enquiry, 1972) and it is estimated that appendicectomy accounts for 40% of all acute operations performed in this country (Shepherd, 1960a). Although the mortality for acute appendicitis is falling, in 1960 500 people died from acute appendicitis and in 1970 only 259 (Registrar General, 1972), a mortality rate in the individual series of about 1.5% (Shepherd, 1960a, Moloney et al., 1950) is still unacceptably high. In his important review of acute appendicitis in 1931, Wilkie emphasises that it is not the typical case of acute appendicitis which is the dangerous one, rather the case with which all surgeons are familiar that presents with either an atypical history or with virtually an absence of abdominal signs. If the mortality and morbidity of the condition are to be reduced, any available ancillary investigation must be considered.

In 1943 Steinart et al. published the first detailed review of the use of the plain abdominal x-ray in the diagnosis of acute appendicitis and others since then have supported the view that a routine plain x-ray can be helpful in the diagnosis (Soteropoulos and Gilmore, 1958; Brooks and Killen, 1965; Graham and Johnson, 1966). This study is an analysis of the plain x-ray findings in 74 cases of acute appendicitis.

METHOD

During a two year period, first at the Royal Infirmary in Edinburgh and later at the Leeds General Infirmary all cases of suspected acute appendicitis were subjected to a routine chest x-ray and erect and supine abdominal x-rays. The diagnosis was confirmed at operation and on pathological findings in 74 cases. At the end of the two year period the x-rays from each of the 74 cases were reviewed.

THE RADIOLOGICAL SIGNS OF ACUTE APPENDICITIS

Nine signs were identified from a review of the literature as being of suggested value in the diagnosis of acute appendicitis (table 1).

1. Localised ileus in the right lower quadrant of the abdomen, shown by loops of distended bowel in that area, or by air fluid levels in the terminal ileum, caecum or ascending colon (Soteropoulos and Gilmore, 1958; Brooks and Killen, 1965; fig. 2).
2. An increase in soft tissue density in the right lower quadrant of the abdomen, shown by a haziness in the right iliac fossa area, or by blurring of the right sacro iliac joint. This indicates either an inflammatory mass or an abscess formation (Brooks and Killen, 1965).
3. Obliteration or widening of the right flank stripe (that is, the radio translucent curve lateral to the peritoneal line

TABLE 1

ACUTE APPENDICITIS

RADIOLOGICAL SIGNS

1. LOCAL ILEUS.
2. SOFT TISSUE DENSITY.
3. FLANK STRIPE OBLITERATION.
4. APPENDICOLITH.
5. PSOAS OBLITERATION.
6. APPENDICULAR GAS.
7. CONVEX LUMBAR SCOLIOSIS.
8. EXTRA LUMINAL GAS.
9. DEFORMED CAECUM.

which is produced by the adipose tissue supporting the peritoneum and transversus abdominis muscle). If the appendix lies laterally in a retrocaecal position the flank stripe is obliterated or becomes less well defined. If the appendix lies medially and causes irritation of the right psoas muscle, splinting occurs and the right flank stripe is widened (Soteropoulos and Gilmore, 1958).

4. The presence of radio-opaque concretions (appendicolith, faecolith, coprolith) in the classical appendiceal positions (Felson and Bernhard, 1947; fig. 1).
5. Blurring or obliteration of the distal third of the right psoas outline caused by an inflamed or oedematous appendix or by muscle spasm (Soteropoulos and Gilmore, 1958).
6. Left convex lumbar scoliosis, indicating reflex guarding of the contents of the right side of the abdomen (Friman-Dahl, 1974a; fig. 3).
7. A gas filled appendix (Musgrove, 1952; Samuel, 1957).
8. The presence of free gas in the intra-peritoneal space (McCourt, 1960) or in the retro-peritoneal space (Sands, 1955; McCourt, 1960).
9. Deformity of the caecal outline - a distended caecal gas shadow distorted by the presence of oedematous tissue or an abscess (Soteropoulos and Gilmore, 1958).

RESULTS

Table 2 lists the occurrence of the radiological signs in 74 patients. In this series, one or other of the radiological signs listed above was found in 48% of the cases studied. The most frequent sign was that of localised ileus which occurred in 39% of the cases. In all but two of the 29 cases showing ileus, air fluid levels were identified on the erect film. In the remaining two cases a dilated caecum was identified on the supine film. An increased soft tissue density was identified in 20% of cases and convex lumbar scoliosis in 14%. The flank stripe sign and psoas obliteration sign were seen in 4% and 8% of cases respectively. In only one case was an appendicolith identified. The deformed caecum sign was eliminated because of difficulty in assessment. In none of the cases did the author identify either intra luminal or extra luminal gas.

DISCUSSION

Localised Ileus

The presence of localised ileus as the most frequent plain x-ray finding was in accord with the other published series. As has been mentioned in the results, all but two of the cases of localised ileus were shown by air fluid levels. The results were comparable with other series. For example, Brooks and Killen (1965) noted air fluid levels in 45% of 114 cases and localised ileus in 33% of 159 cases; Graham and Johnson (1966) quote a figure of 51% for an ileal air fluid level and 46% for a caecal air fluid

TABLE 2

ACUTE APPENDICITIS

RADIOLOGICAL SIGNS - 74 CASES

RADIOLOGICAL SIGN	No	%
1. LOCAL ILEUS	29	39
2. SOFT TISSUE DENSITY	16	22
3. FLANK STRIPE	3	4
4. APPENDICOLITH	1	1
5. PSOAS OBLITERATION	6	8
6. CONVEX LUMBAR SCOLIOSIS	10	14

level. In Soteropoulos's paper (1958) he states that the most important sign is that of the caecal air fluid level which is best seen on the lateral decubitus film, and for which he quotes an incidence of 88% in a series of 25 patients. In this series routine lateral decubitus films were not performed therefore no comment can be made on this statement.

Soft Tissue Density

The soft tissue density rate of 20% in this series again compares with that of Brooks and Killen (1965) (their incidence being 23% in 159 patients). Graham and Johnson (1966) quote a right lower quadrant haze in 12% only. However, they note that this sign was not present in any of the normals which they used as a control group. In both this series and that of Brooks and Killen, the relative density of the right sacro iliac joint line was used as a guide to the soft tissue density sign; no mention of this is made in Graham and Johnson's paper and Soteropoulos does not include the soft tissue density sign in his assessment.

Convex Lumbar Scoliosis

Convex lumbar scoliosis was present in this series in 14% of cases. Graham and Johnson (1966) found it in 31% of their cases but add that it was present in 15% of their normal control group. This highlights the problem of reliability of the sign, for one cannot be sure whether the scoliosis is a genuine sign of splinting of the right iliac fossa or whether it is just the position the patient has taken up while the x-rays are being taken.

Right Flank Stripe Sign

The incidence of blurring, obliteration or widening of the right flank stripe was low in this series. Many of the x-rays, however, were of inadequate quality to adjudicate the signs and were eliminated because of this. Soteropoulos (1958) found the sign to be positive in all but three of his 25 patients, but comments that it is only reliable if the films are of the highest quality and if special views are taken. It should be noted that he states the flank stripe sign is only blurred if the appendix lies retro-caecally and laterally and that in most cases the flank stripe is widened because of the right psoas muscle going into partial spasm from the irritating effect of the inflamed appendix. Brooks and Killen (1965) record the sign in 17 of 88 patients - again they excluded 112 sets of x-rays because of technical quality. It would seem that the sign may be of use therefore only if the films are of the very highest technical quality. This is an unlikely event in the situation of a busy casualty x-ray department.

Deformed Caecum Sign

The deformed caecum sign is suggested by Soteropoulos (1958) and is discussed as follows - "the caecum is frequently distended, the haustrations are prominent and the mucosa coarsened and thickened". He records the signs as being present in all of his 25 patients. The author eliminated this sign from his final figures because it was difficult to evaluate; Brooks and Killen (1965) found the sign positive in only two cases of 159 and Graham and Johnson (1966) do not mention it.

Extraluminal Gas

No cases of visible extraluminal gas were encountered in this series. The literature indicates that it does occur and therefore must be searched for. Brooks and Killen (1965) report extraluminal gas in one of their cases, Graham and Johnson (1966) in one case and in a paper devoted to the subject McCourt (1960) describes six cases. In the latter paper the extraluminal gas is described as arising from two sources - it may be free gas from rupture of the appendix (i.e. in perforated appendicitis) and is seen either under the diaphragm, under the liver or in the peri-appendicular area; or it may be gas which has been formed from decomposition of blood and exudate by organisms in the region of an inflamed appendix. This gas is seen as small bubbles in pockets of fluid (Sands, 1955). In McCourt's six patients, two had free gas and four had "abscess gas". It is said that if the appendix perforates retro-peritoneally, the gas bubbles show in the peri-renal and soft tissue shadows of the lateral abdominal wall (Bird, Fissel and Young, 1948). The bubbles of gas sign should be diligently searched for if an appendix abscess is suggested clinically. The free gas sign is of dubious validity; an appendix usually perforates because its lumen is occluded and this in itself means a free communication with the caecum is unlikely unless the perforation occurs on the base of the appendix.

Intraluminal Gas (Gas in the Appendix)

In its normal position (because it lies below the level of the caecum) the appendix can only remain filled with gas if its communication with the

caecum is occluded and gas forming organisms are present (Bird, Fissel and Young, 1947). Samuel (1957) however, points out that if the appendix remains in its infantile position (that is, in the right upper quadrant) it is the highest point of the right colon, and gas may be seen in it in normal circumstances. One must therefore be careful about recording intraluminal gas as a diagnostic sign. This sign was not observed in my own series. Brooks and Killen (1965) found it in 3 of 137 cases, but neither Graham and Johnson (1966) or Soteropoulos (1958) comment upon it.

Appendiceal Calculi

This is a most important radiological sign. Berg and Berg (1957) quote a 5% incidence for radiologically visible calculi in their series of acute appendicitis, while Steinart (1943) quotes a figure of just over 10% (10 positive cases in 104 patients). A detailed review of appendiceal calculi in this country by Shaw (1965) does not quote a figure for the radiological incidence of the calculus pre-operatively (33% of his appendiceal calculi were visible on x-raying the removed appendix after appendectomy). He says, however, that it is only the bigger ones which are visible on the pre-operative films - presumably he does not quote a pre-operative incidence of visible calculi because all his cases were not x-rayed pre-operatively. In my own series only one out of 74 cases had a visible calculus and it may be that the incidence of visible stones is less in this country, than for instance in America. The demonstration of a radio opaque appendiceal calculus, in the presence of abdominal symptoms, indicates the likelihood of a diagnosis of acute appendicitis (Berg and Berg (1957) quote

a 90% chance) and, furthermore, it would seem that the presence of a calculus indicates a much higher chance of perforation of the appendix - Berg and Berg had a 48% incidence of perforation in their calculus patients; Brady and Carol's incidence (1957) was even higher (32 cases out of 34 reviewed were perforated). It may be that x-ray visible calculi are found in the younger age group. Berg and Berg state the majority of their cases were under 21 years old and that 25% were less than 5 years old. Brady and Carol gave an average age of 20 years (3 - 75 years) for their calculus patients. These figures and facts warrant a careful search for the radio opaque calculus. Indeed, as Berg says, both surgeons and radiologists must remain "coprolith conscious".

SUMMARY

1. In this series of 74 cases the localised ileus sign and soft tissue density sign, with an incidence of 40% and 20% respectively, were the most common signs. The percentage incidence in our series is comparable with that in the available world literature. Both of these signs can be relatively easily evaluated on the routine films.
2. Further study of the caecal fluid level in the lateral decubitus film is needed.
3. The flank stripe sign, psoas obliteration sign and the deformed caecum sign require the highest quality films for their evaluation, a requisite which, in my own opinion, is not compatible with a busy casualty x-ray department films. Similarly, the convex scoliosis sign is only of use if one can be sure that it is "position valid".
4. The appendix stone is an important sign indicating a high chance of acute appendicitis and a high chance of accompanying perforation of that appendix.
5. Extraluminal gas must be sought for, especially if the presence of an abscess is clinically indicated.
6. Intraluminal gas would not appear to be a reliable sign.

CHAPTER 2ACUTE CHOLECYSTITIS

INTRODUCTION

Acute cholecystitis accounted for 20,000 hospital admissions in 1970 (Hospital In Patient Enquiry, 1972); the number of admissions to the surgical ward when compared to acute appendicitis is in a ratio of 1 : 4 (Jones, 1974a). Although the clinical history and physical signs of acute cholecystitis are well known, the patient often presents a problem in diagnosis. This fact is well shown by Essenheigh's series from Oxford (1966). He reviewed 429 patients with acute cholecystitis, of these 97 required a laparotomy within 24 hours of admission: 37 of these 97 cases had a pre-operative diagnosis of acute appendicitis, 2 of perforated peptic ulcer and 10 of peritonitis. Therefore, in this group of patients with a final diagnosis of acute cholecystitis, the initial diagnosis was incorrect in 36% of the cases. From this fact alone must follow, that any aid to the correct diagnosis of acute cholecystitis is mandatory in all cases in whom acute cholecystitis is included in the differential diagnosis. This series reviews the plain abdominal x-rays together with a chest x-ray in 64 cases of proven acute cholecystitis.

METHOD

The patients studied were admitted as emergencies under the author's care at either the Leeds General Infirmary or the Bradford Group of Hospitals. Routine abdominal erect and supine x-rays together with a chest x-ray were performed in all cases in whom a diagnosis of acute cholecystitis was suspected. For the purposes of this study cases considered to have biliary colic were excluded. A clinical diagnosis was

made from the history and physical findings, but the diagnosis was not accepted until a diseased gall bladder was found at operation and pathologically confirmed to show the changes of inflammation. The x-rays were then reviewed retrospectively for the radiological features listed below:

THE RADIOLOGICAL SIGNS OF ACUTE CHOLECYSTITIS (Table 3)

1. The presence of radio-opaque calculi in the position of the gall bladder (figs. 4, 5, 6).
2. The presence of an enlarged gall bladder visible as a soft tissue mass (fig. 8).
3. Localised ileus in the right upper quadrant of the abdomen shown either as
 - (a) gas fluid levels in the small bowel, or
 - (b) gaseous distention of the small bowel, colon or duodenum.
4. Indentation of the distended hepatic flexure of the colon by an enlarged gall bladder.
5. Emphysema of the gall bladder (fig. 9).
6. Free fluid in the abdomen.
7. Right-sided basal chest changes.

RESULTS

The results of the analysis of the plain x-rays of 64 proven cases of acute cholecystitis are shown in Table 4. One or other of the radiological features occurred in 64% of the cases. The most common radiological feature

TABLE 3

ACUTE CHOLECYSTITIS

RADIOLOGICAL SIGNS

1. RADIO-OPAQUE CALCULI
2. SOFT TISSUE MASS
3. LOCALISED ILEUS
4. HEPATIC FLEXURE INDENTATION
5. EMPHYSEMA OF GALL BLADDER
6. FREE FLUID IN ABDOMEN
7. BASAL CHEST CHANGES

TABLE 4

ACUTE CHOLECYSTITIS

RADIOLOGICAL SIGNS - 64 CASES

RADIOLOGICAL SIGN	No	%
1. CALCULI	16	25
2. SOFT TISSUE MASS	13	20
3. LOCAL ILEUS	6	10
4. FREE FLUID	3	5
5. BASAL CHEST CHANGES	6	10

was radio-opaque calculi (in 25%), followed by the presence of a soft tissue mass (in 20%). Evidence of local ileus was present in 10% of cases, as were basal chest x-ray changes. Evidence of free fluid in the abdomen was present in only 5% of cases. Emphysema of the gall bladder and hepatic flexure indentation were not seen in any of the cases in this series.

DISCUSSION

Radio-Opaque Calculi

95% of patients with acute cholecystitis are shown to have gall stones (Glenn and Thorbjarnarson, 1963) but only about 10% of these stones are said to be radio-opaque on the plain abdominal x-rays (McCourt, 1973). In our own series we recorded the presence of radio-opaque stones in 16 out of 64 cases, an incidence of 25%. Because this figure was much higher than that found in the literature, a further series of 50 patients was studied, reviewing the plain control film taken as a routine prior to cholecystography (performed at the Bradford Royal Infirmary). Again, an identical figure of 25% of visible gall stones was obtained. It may be that there is a wide geographical variation of the number of calculi which are radio-opaque (i.e. a geographical variation in the calcium content of gall stones). The appearance of the radio-opaque gall stones was of two varieties: the single mixed gall stone which showed a rounded opacity often with some concentric rings due to the layering of the different substances, or secondly the multiple faceted type of gall stone with angulated edges (figs. 4, 5 and 6). In one case only were gall stones identified in the common bile duct as well as in the gall bladder. In two

cases, multiple stones lay in the fundus of the gall bladder with a separate stone lying some distance away impacted in Hartman's pouch (fig. 7).

Two important points must be remembered regarding radio-opaque calculi:

- (a) the presence of radio-opaque calculi does not necessarily mean the patient has acute cholecystitis. Radio-opaque stones are sometimes present as an incidental finding.
- (b) the presence of a radio-opaque object in the right side of the abdomen is not necessarily a gall stone. The differential diagnosis includes calcified lymph glands (figs. 88,89), appendicoliths, renal calculi (fig. 61), radio-opaque tablets and adrenal calcification (fig. 49). The features of gall stones which allow their differentiation from the other causes are their multiplicity and shape, or the concentric layering described above and produced by alternate layers of calcium, bilirubinate and cholesterol in the mixed type of gall stone.

Calcification of the gall bladder wall may occur in association with repeated attacks of cholecystitis, giving the so called "porcelain gall bladder" appearance on the plain x-ray (fig. 11). This appearance was not identified in any of the cases under consideration.

The Soft Tissue Mass

The obstructed gall bladder distends downwards and medially. In many cases of acute cholecystitis the greater omentum adheres to the gall bladder forming an inflammatory mass (especially if local perforation or gangrene has occurred). The enlarged gall bladder or the inflammatory mass may be shown as a soft tissue mass on the plain abdominal x-ray (fig. 8).

In some cases the pear drop shape of the gall bladder may be visible itself or, in others, a mass may be shown only as a haze in the right upper quadrant of the abdomen. In our series the soft tissue mass was identified in 20% of cases, a figure which compares with that of Salleh and Ballasegaram (1974).

Localised Ileus in the Right Upper Quadrant of the Abdomen

A reflex ileus can be induced in the structures surrounding an acutely inflamed gall bladder (fig. 8). The structures involved may be the stomach, the duodenum, the small bowel and the hepatic flexure of the colon. Ileus of the stomach and colon is usually best shown by gaseous distention on the supine x-ray. In addition to this, gaseous distention fluid levels may be seen on the erect film. Usually it is the ileus of the small bowel and duodenum which show as air fluid levels. The more severe the degree of inflammation the more severe the ileus, thus in the majority of the 10% of cases which showed ileus in our series, the gall bladder also produced a soft tissue mass. The surrounding gaseous distention and fluid levels helped to define the soft tissue mass of the gall bladder.

Free Fluid in the Abdomen

The acute inflammatory process produces an exudate which may show as a diffuse ground glass opacity on the plain abdominal x-rays. Alternatively, it may show as localised collections of fluid or as fluid lying between the loops of bowel. In this series only 3 of 64 cases (5%) showed any evidence of free fluid. In none of these cases was the ground glass opacity of diffuse free fluid found. In two cases the fluid showed as

radio-opaque areas between loops of small bowel and in the third case it was visible as a crescentic shape in the pelvis. In this 64 cases no instances of bile peritonitis were found and therefore I cannot comment on Frimann-Dahl's suggestion that free fluid can develop from an effusion of bile from a non-perforated gall bladder (Frimann-Dahl, 1974a). The results of this series do, however, concur with his statement that free fluid only rarely occurs in acute cholecystitis. Salleh's figures (1974) showed free fluid to be present in only 0.9% of 303 cases.

Basal Chest Changes

Basal changes of the right lung and pleura are stated to accompany the presence of acute cholecystitis. Presumably these are due to poor excursion of the right diaphragm and lung accompanying the pain of the acute inflammatory process. In this series a basal pleural reaction with obliteration of the right costophrenic angle was seen in 10% of cases but none was shown to have a basal atelectasis or right lower lobe collapse. The author found it very difficult to evaluate basal chest changes in the routine chest x-rays taken on the emergency service. Indeed, Frimann-Dahl (1974a) comments that definite chest x-ray changes in acute cholecystitis are rare and Salleh and Ballasegaram do not even mention it in their survey.

Two more groups of plain x-ray signs are said to occur with acute cholecystitis. These signs were not identified in this series but are commented upon for the sake of completeness:

Indentation of the Hepatic Flexure

This sign is well described and illustrated by McCourt, 1973.

It is produced by a combination of signs 2 and 3 described above. The enlarged gall bladder indents the hepatic flexure which is distended by gas as part of the reflex ileus. Salleh found this sign to be positive in 10% of cases and Frimann-Dahl also comments upon it. In spite of the fact that the sign was not seen in any of our series, it would therefore appear from the literature that it is a worthwhile sign and should be looked for when films of acute cholecystitis are reviewed.

Emphysema of the Gall Bladder

(Syn. Acute gaseous cholecystitis, Pneumocholecystitis)

This condition is well documented by Esquerro-Gomez (1963), and is also well illustrated by Frimann-Dahl (1974a) and by McCourt (1973). The condition is characterised by either intraluminal gas or intramural gas. The clinical picture is that of acute cholecystitis but the general condition of the patient is often much poorer than the patient's symptomatology would suggest. The bacteria implicated in the disease are *Escherichia Coli*, a pathogenic *staphylococcus* or *streptococcus* and *Clostridium Welchii*. The first x-ray manifestations are seen about 24 hours after the onset of the symptoms and consist of either a gas filled gall bladder or a gall bladder containing an air fluid level. At a later stage, the characteristic picture of an intramural halo of gas is seen, the gas lying between the mucosa and the muscle layer of the gall bladder. If the inflammation progresses small pericholecystic abscesses form and show up as radiotranslucent shadows around the gall bladder. Very rarely gas may be found in the hepatic and common bile ducts. In my original series, emphysema of the gall bladder was

not seen, but I have since encountered one case. In this case the emphysema was shown as an air fluid level in the gall bladder (Fig. 9). The patient's condition necessitated an emergency operation and a grossly distended gall bladder containing pus was drained.

Biliary Peritonitis

This disease is included here for completeness's sake although the author has not encountered any examples of this since the beginning of his study of acute abdominal x-rays. If the gall bladder ruptures then certain plain abdominal signs may be seen (McCourt, 1973). These are:

1. Visible intra-abdominal fluid collections.
2. Extra alimentary gas bubbles.
3. Opaque gall stones at some distance from the gall bladder.
4. A severe paralytic ileus.

Mention of the plain x-ray features of acute cholecystitis is made in most standard surgical textbooks and further details of the changes are available in the radiological literature. However, little specific information is available regarding the numerical occurrence of each of the signs discussed above. It was therefore of great interest that the results of a recent survey of acute cholecystitis covering 303 confirmed cases by Salleh and Ballasegaram included a detailed study of the plain x-ray features. Their results agreed almost entirely with the author's figures. Table 5 shows the results quoted by Salleh and Ballasegaram.

TABLE 5

The Plain X-Ray Features of Acute Cholecystitis -

Salleh and Ballasegaram (1974)

	No of Cases	%
Vague haze in right upper quadrant	82	38
Enlarged gall bladder shadow	84	38
Calculi	39	17.8
Localised ileus	32	14.6
Pressure on hepatic flexure	10	4.6
Dilatation of duodenal cap and second part of duodenum	7	3.2
Obliteration of fat line	5	2.3
Free fluid in abdomen	2	0.9
Gas in gall bladder or its wall	1	0.5

SUMMARY

1. One or other of the plain x-ray signs of acute cholecystitis was seen in 64% of a series of 64 cases.
2. The most frequent radiological finding is that of radio-opaque gall stones (25%) followed by evidence of a soft tissue density (20%).
3. The hepatic flexure indentation sign and emphysema of the gall bladder were not seen but both should be sought for.
4. Because the diagnosis of acute cholecystitis is by no means straightforward in every case, the results of the author's series suggest that plain x-rays are mandatory in every case of suspected acute cholecystitis.

CHAPTER 3

ACUTE PANCREATITIS

INTRODUCTION

The diagnosis of acute pancreatitis remains one of the most difficult of the acute abdominal emergencies. This is not only because of the extreme variance of the clinical presentation (Pollock, 1959) but also because there is no totally reliable laboratory or radiological aid to its diagnosis (Edmondson et al., 1952). The absolute mortality of the disease is quoted as 11 per million of the population in this country per annum (Registrar General's Statistical Review, 1971) and Trapnell (1974) quotes a mortality for his own series of 590 cases (over a 20 year period) as 20%. These figures indicate both the seriousness of the disease and the necessity for close analysis of every suggested aid to its diagnosis. This series is an analysis of the plain abdominal x-rays and chest x-rays of 34 cases of proven acute pancreatitis.

METHOD

During a three year period, first at Leeds Infirmary and later at the Bradford Royal Infirmary and Bradford St. Luke's Hospital, all cases of suspected acute pancreatitis were subjected to a routine chest x-ray and erect and supine abdominal x-rays. The diagnosis was taken as confirmed if, in addition to the clinical picture of acute pancreatitis, one or more of the following criteria was also present:

1. Serum amylase elevated over 1000 somogyi units in the first 24 hours.
2. The appearances of acute pancreatitis were present at laparotomy.

In this way, 34 cases of acute pancreatitis were confirmed. At the end of the

three year period their plain x-rays were reviewed retrospectively for specific radiological features:

Radiological Changes in the Abdominal X-rays

1. Localised Paralytic Ileus

- (a) duodenal ileus
- (b) gastric ileus
- (c) sentinal jejunal loops
- (d) colonic ileus a) Stuart's sign
 b) Colon cut-off sign

2. Direct visualisation of the pancreas from

- (a) displacement and widening of the duodenal loop
- (b) presence of gas bubbles
- (c) from abscess formation with one or more fluid levels

3. The Presence of Pancreatic Calcification

4. The Presence of Radio-Opaque Calculi

- (a) in the gall bladder
- (b) in the common bile duct

5. Effacement of the psoas and kidney shadows, particularly on the left side

Radiological Changes in the Chest X-ray

1. Elevation of one or both hemi-diaphragms
2. Basal atelectases at one or both bases
3. Pleural effusion on one or both sides

Table 6 lists the radiological signs found in this review.

TABLE 6

ACUTE PANCREATITIS

RADIOLOGICAL SIGNS

A. ABDOMEN

1. DUODENAL ILEUS
2. GASTRIC ILEUS
3. SENTINAL LOOP
4. GENERALISED ILEUS
5. STUART'S SIGN
6. COLON CUT-OFF SIGN
7. PANCREATIC CALCIFICATION
8. CALCULI
9. PSOAS SHADOW OBLITERATION
10. KIDNEY SHADOW EFFACEMENT

B. CHEST

1. ELEVATED DIAPHRAGM
2. PLATE ATELECTASIS
3. PLEURAL EFFUSION

RESULTS

The incidence of each of the radiological signs in 34 cases of acute pancreatitis is shown in tables 7 and 8. The abdominal x-rays were abnormal in 60% of the cases and 25% of the x-rays showed more than one of the specific signs. The chest x-ray was abnormal in 29% of the cases, but in only 3 cases was there an abnormality in both chest and abdominal x-ray.

DISCUSSION

Abdominal Signs

(a) Ileus

The ileus accompanying acute pancreatitis can either be generalised or localised. Generalised ileus is a rare occurrence and was not seen in any of the cases of this series on the admission abdominal x-rays. As would be expected, the radiological picture of generalised paralytic ileus was seen in several cases x-rayed at a later stage in the disease.

(b) Localised Ileus

- (i) Duodenal ileus (fig. 12) - This may manifest as air distention alone or may show as air fluid levels. It is best seen as air fluid levels on the erect abdominal film and occurred in 14% of cases. Both Poppel (1968) and Schultz (1963) comment on the occurrence of duodenal ileus in their reviews but provide no statistics for its occurrence in the plain x-rays. Schultz, however, showed duodenal atony in 10 of his 15 cases of acute pancreatitis studied with acute barium meal and follow through.

TABLE 7

ACUTE PANCREATITIS

RADIOLOGICAL SIGNS - 34 CASES

A. ABDOMEN

RADIOLOGICAL SIGN	No	%
1. DUODENAL ILEUS	5	14
2. GASTRIC ILEUS	10	28
3. SENTINAL LOOP	13	38
4. GENERALISED ILEUS	0	0
5. STUART'S SIGN	1	2.5
6. COLON CUT-OFF SIGN	6	21
7. PANCREATIC CALCIFICATION	0	0
8. CALCULI	0	0

TABLE 8

ACUTE PANCREATITIS

RADIOLOGICAL SIGNS - 34 CASES

B. CHEST

RADIOLOGICAL SIGN		No	%
1. ELEVATED DIAPHRAGM	R	1	21
	L	5	
2. PLATE ATELECTASIS		0	0
3. PLEURAL EFFUSION	R	2	14
	L	3	

Frimann-Dahl (1974c) describes the 'reversed 3' sign on the plain abdominal x-ray, composed of the duodenum outlined by gaseous distention and held inwards to the point of the 3 by the Ampulla of Vater.

- (ii) Gastric ileus (fig. 13) - Similar in origin to the duodenal ileus as a reflex adynamic state, gastric ileus was seen in 28% of cases. It was most easily recognised on the supine x-ray.

It should be remembered that gastric and duodenal ileus are non-specific, that is they occur with other acute abdominal diseases (see, for example, Acute Cholecystitis, Chapter 2).

- (iii) Jejunal ileus (the sentinal loop sign) (fig. 14) - This is the presence of dilated loops of jejunum in the left upper quadrant of the abdomen. It was first described by Grollman, Goodman and Fine in 1950. In this series, a small bowel fluid level was considered pathological if the maximum diameter of the fluid level was greater than 3cms. (the criterion suggested by Stein in 1959). The sentinal loop sign is said to occur in the left upper quadrant or left mid abdomen, occasionally crossing the mid-line to the right (Stein, 1959). In this series the sign was present in 38% of cases. In every case there was more than one dilated loop (usually two or three) and in addition there were several smaller air fluid levels seen on the erect film in the same region. The sentinal loops were visible on both the erect

and supine films and although in all but one case they were in the left upper quadrant (the exception being in the right upper quadrant) they lay towards the mid abdomen and not immediately under the diaphragm. In comparison, Stein (1959) identified the sentinel loop sign in 55% of 61 cases, Schwartz and Nadelhalt (1957) found sentinel loops in 45% of their series and Brascho (1962) in 44%.

(iv) Colonic ileus

Stuart's sign (fig. 15) - Stuart proposed his diagnostic sign in an article written in 1956 in which he stated that the transverse colon was often emptied of gas while the ascending and descending colon were distended with gas. In the author's series the sign was found in only one case. This sign is not mentioned in the reviews by Stein (1959), Schultz (1963) or Poppel (1968). Pollock (1959) mentions that, although looked for carefully, in none of his cases was the sign visible. These results would suggest that the sign is of no great diagnostic value.

The Colon Cut-Off Sign (fig. 16) - This sign was first described by Price in 1956. The large bowel is dilated up to an area of narrowing at the splenic flexure, the appearances he says being similar to those of a large bowel obstruction. The "cut-off" occasionally occurs more proximally, for example at the mid transverse colon level (Brascho, 1962) or at the hepatic flexure (Price, 1956). In his recorded series Schwartz (1957) carried out

barium enema studies on three cases and showed that the obstruction was caused by spasm of the large bowel and that at a later date oedema of the mucosa in this area could be demonstrated. It is thought that an anatomical explanation for the sign can be made, in that the exudate from the acute pancreatitis spreads between the leaves of the transverse mesocolon and from there along the phreno-colic ligament to the area of the splenic flexure. This explanation is given by Brascho, but Schwartz puts forward a second explanation that the distention is the result of a visceral reflex. The colon receives its sympathetic supply up to the splenic flexure from the superior mesenteric plexus and thus the pancreatitis could cause a reflex excitation of the sympathetic supply via the superior mesenteric plexus alone. In this series a colon cut-off sign occurred in six cases (21%). In each case the cut-off was at the splenic flexure. Although the appearances are said to mimic large bowel obstruction, the author's positive cases were shown as gaseous distention of the ascending and transverse colon, best shown on the supine film. The bowel was "full of air" rather than grossly distended and air fluid levels were not identified on the erect film. The importance of this sign is stressed by Schwartz and Nadelhalft (1957) and Brascho et al. (1962). The latter found the sign to be present in 30 of 54 cases (56%). In 28 cases the cut-off was at the splenic flexure, the two other cases being at the mid transverse colon level.

(c) Direct Visualisation of the Pancreas

The inflammatory process of acute pancreatitis causes oedema and swelling of the head of the pancreas with widening of the duodenal loop. Theoretically if the duodenum is gas filled this widening should be visible on the plain x-rays. The author was not able to identify this on any of his films and feels that it is a sign more relevant to barium studies (Poppel, 1968). Direct involvement of the pancreas may be shown by the presence of gas bubbles from a gas forming organism or by one or more large air fluid levels from formation of a pancreatic abscess (Poppel, 1968). Neither of these pathological signs was seen in this series.

(d) Pancreatic Calcification (fig. 17)

Calcification of the pancreas occurs in chronic pancreatic disease. Stein et al. (1959) describe calcification or calculi to be present in 17% of their series (10 of 61 cases). In Pollock's series (1959) from a British source, no mention is made of calcification and in this series of plain x-rays, none with calcification was seen. Undoubtedly the high American incidence is based on the differing aetiology and pathology of the disease between this country and the United States of America.

(e) Biliary Tract Calculi

Although 50% of cases of acute pancreatitis in this country are said to be associated with biliary tract disease, in none of this series was a radio-opaque calculi seen in either the gall bladder or in the common bile duct. This is rather surprising in view of the high incidence of radio-opaque stones seen in the gall bladder series. No explanation can be

offered and it may well be worthy of further investigation from a clinical point of view.

(f) Effacement of the Kidney and Psoas Shadows

Loss of the shadow of the left kidney and psoas muscle is caused by the presence of local oedema or fluid in the peritoneal cavity (Poppel, 1968). Initially an attempt was made to include these signs in this series, but because of difficulty in interpretation, the signs were later eliminated. Films must be of high quality to show the psoas and kidney outlines well and in many of our cases this was not achieved. Stein et al. (1959) also eliminated the sign because of its lack of specificity.

(g) Fat Necrosis and Bone Infarction

The areas of fat necrosis caused by the enzyme lipase released from the pancreas (and well known to the surgeon who carries out a laparotomy for acute pancreatitis) are said to be visible on the plain x-ray (Baylin, 1944). They were not identified in this series. Similarly, circulating enzymes can cause bone infarction by producing intra-medullary fat necrosis (Immelman et al., 1963). This latter finding is more common in chronic pancreatitis and was not seen in my cases.

(h) The Chest X-Ray

In this series of 34 cases, chest x-ray changes were detected in 29%, a figure midway between that quoted by Fishbine etal., (1962) who found changes in 14.2% of cases and Stein et al., (1959) who found changes in more than 50% of cases.

The changes of elevation of the diaphragm and basal atelectasis are non-specific changes which accompany the primary intra-abdominal inflammatory disease and are caused by diaphragmatic irritation or visceral distension. It is thought, however, that the pleural effusion described in acute pancreatitis (fig. 18) is the result of the primary pancreatic pathology rather than a non-specific secondary event. It is suggested that the pancreatitis causes a discharge of the pancreatic enzymes into the thoracic duct and that a transmural migration of pancreatic fluid occurs from the duct into the extra pleural space (Fishbein, 1962). These enzymes cause a chemical reaction which in turn cause the pleural effusion. In this series elevation of the diaphragm was the most frequent finding, and in all but one case it was the left diaphragm which was elevated. A pleural effusion was found in 5 cases, 3 on the left side and 2 on the right, giving an overall incidence of 14%.

CONCLUSION

The results of this study, in which the abdominal x-rays were abnormal in 60% of cases and the chest x-ray in 29%, indicate that the plain x-ray should be used in the diagnosis of acute pancreatitis. Although many of the signs described are both non-specific and difficult to interpret, they provide valuable evidence in this, the most difficult of acute abdominal diseases to diagnose. Indeed, it should be noted that Stein (1959) in his review, records that the radiologist suggested the diagnosis of acute pancreatitis, before it was even considered by the clinician, in 7% of the cases under review.

SUMMARY

1. 60% of the plain abdominal x-rays were abnormal in 34 cases of acute pancreatitis.
2. The most frequent abnormality was the sentinel loop sign (38%) and the colon cut-off sign (21%).
3. The other signs described were considered to be non-specific.
4. 29% of the chest x-rays were abnormal, an elevated diaphragm being present in 21% of cases and a pleural effusion in 14%.
5. The results indicate that plain x-rays are helpful but not diagnostic in cases of acute pancreatitis.

CHAPTER 4PNEUMOPERITONEUM

INTRODUCTION

The causes of pneumoperitoneum in the acute abdomen are shown in Table 9. In the author's series of pneumoperitoneum which included 38 cases, the underlying cause in 86% of these was a perforated duodenal ulcer. The remaining 4 cases consisted of 3 perforated gastric ulcers (7%) and one case of perforated diverticular disease. Because such a large part of the series were due to a single aetiology it was decided to study these cases as a separate entity. A brief review of the other causes of pneumoperitoneum is included at the end of the chapter.

TABLE 9

THE AETIOLOGY OF PNEUMOPERITONEUM

1. STOMACH AND DUODENUM

- (a) perforated duodenal ulcer
- (b) perforated gastric ulcer - benign or malignant
- (c) traumatic perforation of the stomach

2. SMALL INTESTINE

- (a) tuberculous ulceration
- (b) perforated Meckel's diverticulum
- (c) typhoid perforation
- (d) trauma
- (e) regional ileitis

3. APPENDIX

- (a) free air
- (b) gas bubbles in abscess formation

4. THE LARGE BOWEL

- (a) perforated carcinoma
- (b) caecal blow-out due to more distal obstructing carcinoma
- (c) perforation of a pneumatosis coli
- (d) perforation of a volvulus
- (e) perforation of diverticular disease

5. IDIOPATHIC PNEUMOPERITONEUM

THE PLAIN X-RAY IN PERFORATED DUODENAL ULCER DISEASE

Introduction

No single set of figures can be provided for the incidence of perforated peptic ulcer because the incidence varies both between countries and within individual countries (Jones, 1974b). For example, Sweden shows an incidence of 12/100,000 people (Lazarus, 1964) while Israel shows an incidence of only 5/100,000 people. Within Great Britain the incidence in Glasgow is 23/100,000 population (McKay, 1966) while in Oxford it is only 10/100,000 (Sanders, 1967). Again the ratio of gastric ulcer to duodenal ulcer varies from place to place, e.g. in 1957 in Aberdeen the ratio of duodenal ulcer to gastric ulcer was 17 : 1 (Webster and Weir, 1958) while in Oxford in 1957-63 it was 4 : 1 (Sanders, 1967). It is difficult to calculate the exact figure for the Leeds Area but I estimate that 50 cases of perforated peptic ulcer each year are treated in the two major teaching hospitals, giving an incidence of 20/100,000 of population. In my own series the ratio of perforated duodenal ulcer to gastric ulcer was 12 : 1. Because this ratio was so high it was decided to exclude the gastric ulcers from the present series in order to make the series more specific.

In a typical case of perforated duodenal ulcer, the diagnosis is rarely in doubt. De Bakey (1940) found the diagnosis to be correct in 83 - 90% of patients. However, any doubt that exists is much reduced by the demonstration of free intra-peritoneal gas. The plain x-ray is therefore an integral part of the management of a suspected perforation case. This initial series studies the plain x-ray findings in 35 cases of

perforated duodenal ulcer disease.

METHOD

A routine erect chest x-ray together with erect and supine abdominal x-rays were performed in every case of suspected duodenal ulcer admitted to the General Infirmary at Leeds during the period 1972-73. Lateral decubitus films were not routinely taken but were used in two cases when ^{the} patient was judged too ill to be sat erect. The diagnosis of perforated duodenal ulcer was accepted only if confirmed at subsequent laparotomy. The radiographs were reviewed retrospectively for the radiological findings quoted in table 10.

RESULTS

The percentage incidence of the radiological signs in 35 cases of perforated duodenal ulcer are shown in table 11. Pneumoperitoneum was present in 59% of cases, that is in 20 of the 35 cases, and in all but two the air was seen under the diaphragm. Of these cases with air under the diaphragm, in 28% (9 cases) the air was visible as a sickle and in 28% (9 cases) as an air fluid level (figs. 21, 22 and 23). Of the cases with a sickle of air, 2 had a sickle on both sides, 5 had a sickle only on the right side and 2 had a sickle only on the left side. Of the patients with an air fluid level, 6 had an air fluid level on both sides, one case had only an air fluid level on the right, and 2 cases had only an air fluid level on the left (see table 12). Gas was seen under the liver in 3 cases (fig. 26); in 2 of these cases air was also present under the diaphragm. In one of these 2 cases when a lateral decubitus film was taken air was seen under the anterior abdominal wall (fig. 24). Free fluid was seen around the stomach,

TABLE 10

RADIOLOGICAL FINDINGS IN PERFORATED PEPTIC ULCER DISEASE

1. Free intraperitoneal gas, shown as:

- (a) Erect film (i) air under one diaphragm)
 (ii) air under both diaphragms) sickle-shaped
 (iii) air and fluid under one diaphragm
 (iv) air and fluid under both diaphragms
 (v) gas bubble under the liver
- (b) Lateral decubitus film (i) air in iliac fossa
 (ii) as a band from liver to pelvis
 (iii) under the costal arch

2. Free fluid in the peritoneum shown as:

- (a) Dense shadow around the stomach
- (b) Beneath the liver edge causing blurring of the liver margin
- (c) Between the loops of small bowel causing a dense irregular network
- (d) In the peritoneal flanks
- (e) In the pelvis
- (f) Free under the diaphragms as air fluid levels as mentioned above.

3. Direct visualisation of the ulcer by gas in the duodenum shown as:

- (a) Ulcer niche
- (b) Distorted duodenal cap

4. Generalised paralytic ileus

5. Chest X-Ray Changes:

- (a) Basal atelectasis
- (b) Elevated diaphragm
- (c) Pleural effusion

TABLE 11

PERFORATED DUODENAL ULCER
RADIOLOGICAL SIGNS - 35 CASES

RADIOLOGICAL SIGN	No	%
1. GAS UNDER DIAPHRAGM - SICKLE	9	28
2. GAS UNDER DIAPHRAGM - AIR/FLUID LEVEL	9	28
3. GAS UNDER LIVER	3	9
4. GAS ON LATERAL X-RAY	1	3
5. FREE FLUID AROUND STOMACH	3	9
6. FREE FLUID AROUND LIVER	0	0
7. FREE FLUID AROUND BOWEL	3	9
8. FREE FLUID IN FLANK	2	6
9. FREE FLUID IN PELVIS	3	9
10. ULCER SHOWN AS NICHE	1	3
11. ULCER SHOWN BY DISTORTED DUODENUM	0	0
12. PARALYTIC ILEUS	3	9
13. CHEST X-RAY-ATELECTASIS	0	0
14. CHEST X-RAY - ELEVATED DIAPHRAGM	3	9
15. CHEST X-RAY - PLEURAL EFFUSION	0	0

TABLE 12

PNEUMOPERITONEUM - breakdown of the 20 cases

	R.	L.	Both	Total
1. Sickle	5	2	2	9
2. A/F Level	1	2	6	9

(2 cases present with air not under diaphragm:
one case with air under liver alone, one case
with air on lateral decubitus film - erect film
not taken)

around the bowel and in the pelvis in 9% of cases in each of these sub-headings (fig. 20). In the flank it was seen in 6% of cases, that is in 2 cases. The distribution of this free fluid in the 7 positive cases is as shown below in table 13.

In only one case was an ulcer niche identified and in none of the cases was a distorted duodenum identified. In the chest x-ray series an elevated diaphragm was found in 12% of the cases, that is in 4 of the cases. In none of the cases was atelectasis or a pleural effusion identified.

DISCUSSION

Pneumoperitoneum

The first factor of importance in the demonstration of pneumoperitoneum is the x-ray routine used. In this series, patients received three routine x-rays, in the following order:

1. a supine film of the abdomen with vertical x-ray beam
2. an erect film of the abdomen with horizontal x-ray beam
3. an erect film of the chest, to include the diaphragm

It was estimated that the patients had maintained an erect posture for no longer than three minutes when the erect chest x-ray was taken. In only two cases was the patient considered too ill for these routine films to be obtained, and in these two cases a supine chest and a left lateral decubitus film with horizontal x-ray beam were taken. In his book

TABLE 13

DISTRIBUTION OF FREE FLUID IN 7 CASES OF
PERFORATED DUODENAL ULCER

Case	Stomach	Liver	Bowel	Flank	Pelvis
1	+		+		
2	+				
3			+	+	
4				+	+
5					+
6			+		+
7	+				

+ = fluid present

"Roentgen Examination in Acute Abdominal Diseases", Frimann-Dahl (1974d) states that the incidence of pneumoperitoneum varies from 65 - 90% depending on the extent of the examination. His routine was to take a supine x-ray followed by a lateral decubitus film with horizontal x-ray beam. An upright film was only taken if the patient's condition allowed. If no free air was detected with these films, the patient was placed on his side "for a while" (no time stated) and a further lateral decubitus film was taken. In addition, he stated that special views may be required for demonstration of the ulcer niche sign, that routine screening of the abdomen may show small collections of gas which would not be visible on the ordinary films, and that if a naso-gastric tube is passed and the stomach aspirated the incidence of pneumoperitoneum will increase.

Miller and Nelson (1971) in their detailed work considering the demonstration of small amounts of free intra-peritoneal gas in both animals and in man describe a clinical routine in which the patient maintains the left lateral position on the x-ray trolley for 10 - 20 minutes. In the National Health Service situation, I question the practicability of the above regimes. Firstly, the patient is ill, in pain and will not tolerate extensive investigation and secondly, the x-rays are usually performed by radiographers in busy, under-staffed emergency departments or in the middle of the night with a skeleton staff on duty.

The second factor of importance in the demonstration of pneumoperitoneum is interpretation of the films. Frimann-Dahl (1974d) says that if free air is found in one x-ray position, it is usually found in the others (i.e. an erect film of any type should be sufficient)

but adds the rider that a small gas bubble may only be visible on only one view.

In retrospect the author feels that this series should have routinely included a lateral decubitus view.

The recognition of the sub-diaphragmatic air on the erect film may prove difficult. This is especially so on the left side where its differentiation from an air fluid level in the stomach has to be made.

Aids to differentiation are:

1. a second x-ray taken after aspiration of the stomach can be helpful as this may remove the air from the stomach air fluid level;
2. food remnants in the stomach can cause the gastric fluid level to be laminated or fuzzy - the fuzzy fluid level sign of Caruso and Berk (1971); the air fluid level of free gas is neither fuzzy nor laminated;
3. when free fluid has collected on the left side the upper pole of the spleen may be shown, but not when the gas is in the stomach.

When the gas is collected on the right side it is generally more easily recognised because of the relative density of the liver. When the gas appears as a sickle the differentiation from a stomach gas fluid level is obviously easier. In this series, the results showed a sickle on the right in five cases and a sickle on the left in only two cases. As regards the air fluid level cases, in only three cases was the air fluid level not present on both sides and in only two of these three cases was the air fluid level on the left side (i.e. in only two of the positive cases was there a problem of gastric fluid level versus free air).

Pneumoperitoneum was found in this series with an overall incidence of 59% in 35 cases. This was much lower than the incidence quoted in the

standard surgical textbooks. For example, the incidence quoted in Bailey and Love's 'Textbook of Surgery' (1975) is 70% and in Wastell's 'Chronic Duodenal Ulcer' (1972) 80%. Unfortunately no references are given in either of these textbooks and it is not possible to identify the source - perhaps they are figures 'handed down' from one editor of the textbook to the next, as so frequently happens. The only recent figure available in the literature for the incidence of pneumoperitoneum in perforated duodenal ulcer is of 61% quoted by Wellwood et al. (1971) in their paper on the use of the acute gastrographin meal in the diagnosis of perforated ulcers. It would seem therefore, if we accept that it is unlikely that the textbook figures quoted above are the result of extensive routine radiology (as described earlier), that the incidence of pneumoperitoneum has fallen. This apparent fall in the incidence of pneumoperitoneum was worthy of further study and a second series of patients was therefore studied in a prospective manner. Again, the overall incidence of pneumoperitoneum was found to be approximately 60%, but the incidence of pneumoperitoneum in those patients with perforation times of longer than 8 hours showed a marked increase. With modern trends towards quicker hospitalisation of the ill patient, few patients are seen with a prolonged history of perforation, the majority in our series (70%) being in hospital within 8 hours of the onset of symptoms. It would seem, therefore, that the quicker hospitalisation in more recent times is likely to be responsible for the apparent fall in incidence of pneumoperitoneum shown in our patients. This study has been submitted for publication to the Journal of the Royal College of Surgeons of Edinburgh, the full text of

the article being included in appendix II of this thesis.

To complete the discussion of perforated duodenal ulcer, the remaining radiological plain x-ray signs are discussed:-

Air seen under the liver

This was seen in three cases. In two of these the air was also visible under the diaphragms. The author found that gas under the liver was a most difficult radiological finding to identify.

The Supine X-ray

In reviewing this series of x-rays, the supine x-ray was not found to be useful in the identification of free gas. However Frimann-Dahl (1974e) states that moderate amounts of free gas can be identified as translucencies lying between the loops of small bowel in the mid abdomen or in the epigastrium. When large amounts of free gas are present, then the outline of the intestinal wall may be visible - the so called 'table-contour' sign of Lavine and Kaufmann (1957). This sign has since been identified on several occasions, its main importance being in the patient who is too ill for erect films to be taken.

Free Fluid in the Peritoneum

In this series an air fluid level was present in 28% of cases and free fluid around the bowel, stomach, flanks or pelvis in a further 20% of cases. This gives an overall incidence of free fluid in 48% of cases. (1974d)
Frimann-Dahl/quotes a figure much higher than this (60%). The air fluid level has been discussed earlier. Free fluid elsewhere, was seen around the stomach in three cases and as an irregular network of dense bands between the small bowel in a further three cases. In the pelvis it was

seen as a crescentic shape in the lesser pelvis in three cases. Free fluid in the flank showing as a broad radio dense outline with wedging between the bowel was only recognised in two cases. A well illustrated account of free fluid in the peritoneum is available in Frimann-Dahl's book (19741). The explanation for the difference in incidence of this sign between this series and that of Frimann-Dahl is presumably due to the later's expertise in the demonstration of free fluid.

The perforated ulcer shown as a niche or a distorted duodenum (fig. 25)

In this series, the ulcer niche sign was demonstrated in only one case but was well shown beyond any doubt. A gas filled distorted duodenum was not identified with any certainty. Again, recognition of these two signs is due to the work of Frimann-Dahl in 1948. In a series of 268 cases the crater was shown in 22 instances. He states that systematic examination has shown it in 10% of all subsequent cases. It appears that this work was performed mainly in the study of gastric ulcers and although Frimann-Dahl states that the sign is also applicable to the perforated duodenal ulcer, no incidence statistics are quoted for this.

Paralytic ileus

This was seen in only three cases. It is said that little reaction in the intestine occurs with a duodenal perforation until the perforation has been present for 7 - 8 hours (Frimann-Dahl, 1974d). All three of the positive cases were late perforations.

The chest x-ray

Atelectasis and pleural effusion were not recorded. Elevation of the diaphragm occurred in three cases (9%) and in all three of these cases

an air fluid level was also present under the left diaphragm. It was therefore most probably a splinting effect.

Emphysema of the posterior abdominal wall

The cases in this series were anterior or supero-lateral perforating ulcers and posterior perforations were not included. In the posterior perforating duodenal ulcer, extensive emphysema can occur on the posterior abdominal wall showing as small air bubbles (Frimann-Dahl, 1974d). The author had not encountered this sign until recently:

Case History

In November 1975, an 85 year old blind lady was admitted to the Leeds General Infirmary as an emergency with a 36 hour history of severe generalised abdominal pain of sudden onset. She admitted to a past history of indigestion for five years. On examination she was dehydrated and ill with diffuse abdominal tenderness and rebound tenderness. Plain x-rays of the abdomen showed air fluid levels in the small bowel, but no other specific radiological features were noted pre-operatively. At operation on the evening of admission, a large abscess was found in the retroperitoneal position posterior to the first part of the duodenum, due to a posterior perforated duodenal ulcer. Review of the plain abdominal x-rays post-operatively showed bubbles of gas in the retroperitoneal area (fig. 19).

Other Causes of Pneumoperitoneum

In this personal series, the only other cause of pneumoperitoneum encountered was a single case of perforated diverticular disease. Since ending the series, the author has encountered two further cases of free gas:

1. perforated carcinoma of the caecum which caused a large collection of gas seen on the lateral decubitus film (fig. 24).

2. a perforated cyst in a patient suffering from pneumatosis cystoides.

For completeness, a review of the other recorded causes of free gas in the peritoneum is given, together with the appropriate reference for each case:-

1. Traumatic Perforation of the Stomach

(a) in infants: causing the football or air-dome sign (Miller, 1960).

(b) in adults: due to endoscopic manipulations - with or without demonstration of a perforation site (Berk, 1946).

2. Small Intestinal Perforation, due to

(a) tuberculous ulceration: Sweatman and Wise (1959) record pneumoperitoneum in 2 - 7% of all cases of gastrointestinal tuberculosis.

(b) typhoid perforation: Böhrrer (1966) showed free gas in 6 of 11 cases.

(c) regional ileitis: Wayer and Lithgow (1967) showed free gas in 2 of 28 cases of small bowel perforation due to Crohn's disease.

(d) trauma: Fitzgerald et al. (1960) discussed 15 patients with small bowel perforation due to trauma in only 2 of which was free gas visible on x-ray.

3. Perforated Meckel's Diverticulum

Enge and Frimann-Dahl (1964) reviewed 50 cases of perforated Meckel's diverticulum, in which 2 had demonstrable free gas.

4. Jejunal Diverticulitis

Armitage (1970) recorded 4 cases of pneumoperitoneum in association with a perforated jejunal diverticulum.

5. The Large Bowel

- (a) perforated carcinoma: either at the site of the tumour or more proximally due to obstruction with stenosal ulceration (Glenn and McSherry, 1971; Donaldson, 1958).
- (b) perforation of gas cysts in Pneumatosis Coli: An example of pneumatosis coli visible on plain x-ray is shown in figure 73. Pneumoperitoneum has been reported in association with this disease in adults (Elliott and Elliott, 1963) and also in children (Bilger, 1956).
- (c) perforation of large bowel volvulus: the presence of pneumoperitoneum in association with sigmoid volvulus is stressed by Frimann-Dahl (1974i).
- (d) perforation of large bowel diverticular disease: radiological demonstration of free gas in perforated colonic diverticular disease is said to occur in 25% of cases with peritonitis from this cause (Dawson, 1965)

6. Idiopathic Pneumoperitoneum

In this group, free gas is demonstrated on the x-ray but no gastrointestinal perforation can be found to explain it. Examples of conditions associated with this entity are: peptic ulcer, pulmonary peritoneal fistulae and cardiovascular accidents (Felson and Wiot, 1973; Norpath, 1950).



SUMMARY

1. Pneumoperitoneum was present in 59% of 70 cases of perforated duodenal ulcer. A reason for the apparent fall in incidence of this pneumoperitoneum is suggested.
2. The remainder of the plain x-ray signs in perforated duodenal ulcer occurred in a much smaller percentage of cases but nevertheless must be looked for.
3. Of 35 cases of pneumoperitoneum reviewed in the first series, all but one were due to gastric or duodenal perforation.
4. The other causes of pneumoperitoneum are briefly reviewed from the literature.

CHAPTER 5

INTESTINAL OBSTRUCTION

Part 1: Small Bowel Obstruction

INTRODUCTION

The Registrar General's figures in 1940 for mortality from obstruction without mention of hernia and for hernia with obstruction were 55 and 60 deaths per million of population, per year, respectively. In 1968, these figures had fallen to 22 and 18 deaths per million, per year, respectively. The mortality from intestinal obstruction is therefore falling, but when it is remembered that the mortality figures for acute appendicitis have fallen from 55 deaths per million, per year to 8 deaths per million per year over the same 28 year period, it would be difficult to be satisfied with the reduction in mortality from obstruction which has been achieved. It is therefore appropriate that any aid to diagnosis of acute intestinal obstruction must receive the closest of attention, and if indicated, the most full usage. Plain x-rays of the acute abdomen are of use in the diagnosis of obstruction, its site, its degree and its type.

This chapter studies in detail the plain x-ray findings in 42 cases of small bowel obstruction admitted under the author's care over a three year period and correlates the findings with the clinical diagnosis. In this series, the term "small bowel obstruction" is used to include only those cases in which a mechanical obstruction to the passage of content along the intestine is present. Those cases in which a paralytic element was prominent have been excluded.

For the purpose of this series, the following classification of the aetiology of small bowel obstruction has been used:

(a) Extrinsic lesions

- | | | |
|-----------------------|---|--|
| 1. bands or adhesions | } | In these groups the obstruction
may be <u>SIMPLE</u> or
<u>STRANGULATING</u> |
| 2. external herniae | | |
| 3. internal herniae | | |
| 4. carcinomatosis | | |

(b) Intrinsic lesions

1. tumour
2. intussusception
3. obturation
4. inflammatory disease

The term "simple bowel obstruction" is used to signify interference with the continuity of the small bowel without compromise of the blood supply of the bowel. The simple obstruction can be complete or incomplete. The term "strangulation" is used to denote an element of interference with the blood supply of the bowel due to the obstructing lesion.

MATERIALS AND METHODS

Over a period of 3 years, any patient suspected of suffering from small bowel obstruction and managed under the author's care, received a routine chest x-ray, and erect and supine abdominal x-rays. A record of the final diagnosis including operative findings was kept. Forty-two cases of small bowel obstruction were studied in this way, the x-rays being retrospectively reviewed for the following radiological signs:

RADIOLOGICAL SIGNS OF OBSTRUCTION

SIMPLE OBSTRUCTION

1. Gaseous distention of the small bowel proximal to the site of the obstruction (Schwartz, 1911; fig. 28).
2. Transverse arrangements of distended small bowel loops - best seen on a supine x-ray (fig. 28).
3. Gas fluid levels in the small bowel (Schwartz, 1911; figs. 27,35).
4. Hoop shaped loops of small bowel - best seen on an erect x-ray (fig. 27).
5. The String of Beads sign (Frimann-Dahl, 1960; fig. 31).
6. The gas streak or positive stretch sign (Williams, 1964).

STRANGULATING OBSTRUCTION

1. The coffee bean sign of Mellins and Rigler (1954), (fig. 30).
2. The pseudo-tumour sign of Frimann-Dahl (1944), (fig. 29).
3. The fixed loop of bowel on multiple x-rays (Mellins and Rigler, 1954; figs, 32,33).
4. The absence of valvulae conniventes and "flattening" of the small bowel outline in a single loop (Levin, 1973).
5. The absence of small intestinal gas in a patient suspected clinically of having small bowel obstruction (Frimann-Dahl, 1974f).
6. The presence of very long small bowel fluid levels (Mellins and Rigler, 1954).

The following signs were also assessed for their value in

predicting the level of the small bowel obstruction from the radiographic appearances:

1. The presence of the rings of the valvulae conniventes of the jejunum (herringbone appearance).
2. The relative flattening and smooth outline of the walls of the ileum.
3. The number of distended loops seen (more loops, the lower the obstruction).
4. Pre-stenotic loop which is more hoop shaped and more expanded than the other loops.
5. The point of obstruction is usually lower than the most distal gas fluid level.
6. The central distribution of the small bowel compared to the peripheral distribution of the colon.

RESULTS

The aetiology of small bowel obstruction in the 42 cases is shown in Table 14. Twelve cases of obstruction were due to adhesions, two of which showed definite evidence of strangulation and ten of which were classified as simple. Over the same period 22 cases of external herniae containing small bowel received operation. Of these, eight were femoral, two were incisional, two were umbilical and ten were inguinal. Small bowel resection was carried out for non-viable bowel in three of the femoral herniae, and for two of the inguinal herniae. Two cases of internal herniae were found, in one of which the small bowel had herniated through

TABLE 14

AETIOLOGY OF 42 CASES OF SMALL BOWEL OBSTRUCTION

DIAGNOSIS	NO OF CASES
1. ADHESIONS AND BANDS	12
2. EXTERNAL HERNIAE	22
3. INTERNAL HERNIAE	2
4. CARCINOMATOSIS	2
5. TUMOUR	1
6. OBTURATION	1
7. INFLAMMATORY DISEASE	2

a defect in the broad ligament and in the second of which the small bowel had herniated into the foramen of Winslow. Two cases of diffuse carcinomatosis were operated on in which the small bowel was obstructed due to peritoneal metastases. One tumour of the small bowel was found with multiple lymphosarcomas of the small bowel causing obstruction. One case of gall stone ileus was present in the series, the obstruction being 30cms from the ileo caecal valve by a single large gall stone. Two cases of inflammatory disease presenting with symptoms and signs of small bowel obstruction were subjected to laparotomy. In both cases the diagnosis was Crohn's disease.

In Table 15 the results of all cases of small bowel obstruction (42 cases) are recorded. Gaseous distention was absent from three cases, two of them adhesive obstruction and one a strangulated hernia. Gas fluid levels were seen in all but one case, this being a case of strangulated obstruction which is discussed later. The transverse loop arrangement was present in only 36% of the cases and hoop loops were seen in 55%. The string of beads sign was identified in 10% of cases and in 5% a gas streaking sign was present. The fixed loop sign was identified in one case only (again a strangulated obstruction). The coffee bean sign was not seen. In 60% of cases was the colon considered to be empty of gas and faeces. In Table 16 a detailed analysis of the 10 cases of simple adhesive obstruction is shown. No percentages are calculated because of the small number of cases. The most reliable sign is, of course, air fluid levels which were present in all the cases. Gaseous distention was absent in two cases. The number of air fluid levels present varied from

TABLE 15

SMALL BOWEL OBSTRUCTION
RADIOLOGICAL SIGNS IN 42 CASES

RADIOLOGICAL SIGN	No	%
1. DISTENDED SMALL BOWEL	39	92
2. GAS FLUID LEVELS	41	97
3. TRANSVERSE LOOPS	14	36
4. HOOP LOOPS	22	55
5. STRING OF BEADS	4	10
6. GAS STREAKING	2	5
7. SOFT TISSUE DENSITY	-	0
8. COFFEE BEAN SIGN	-	0
9. COLON EMPTY OF GAS & FAECES	25	60
10. FIXED LOOP SIGN	1	2.5

10 - 20 in number with an average of 13.7. The maximum length of fluid levels seen was 10cms. Hoops were seen in seven of the 10 cases and of this seven, two had hoops with air fluid levels at the same height and five cases had hoops with air fluid levels at different heights.

Transverse loops were seen in six of the cases and a string of beads sign in three. Gas streaking was present in two cases. In only two cases could a definite height of obstruction be given which correlated with the later clinical diagnosis.

DISCUSSION

SIMPLE MECHANICAL OBSTRUCTION

This is the group of obstructions in which the small bowel lumen is obstructed at one place by a single adhesion, group of adhesions or by a kink in the bowel produced by adhesions. In this series simple obstruction accounted for ten of the 42 cases (23%). The basis of the production of both the clinical and radiological signs of the obstruction is the prevention of forward passage of intestinal contents. In the case of simple obstruction, the intestinal contents are the fluid produced by the intestinal mucosa and the gas which the patient swallows. It should be noted that gas in the obstructed intestine is not, as was once postulated, produced by the intestine itself (Anderson and Ringsted, 1943; Frimann-Dahl, 1951). The bowel proximal to the stenosis becomes greatly distended with gas and fluid while the bowel distal to the obstruction becomes progressively emptied of gas, faecal material and faecal content. The radiological signs produced by this physiological sequence have been listed in Table 15 and

their incidence in ten cases of simple adhesive obstruction is shown in Table 16. Each sign is now discussed in more detail.

Gaseous Distention of Small Bowel

Gaseous distention of the small bowel proximal to the site of obstruction can be detected as early as three hours following the onset of obstruction (Cantor and Reynolds, 1957). As a general rule the longer the period of obstruction the greater the gaseous distention. However, this does not hold in certain cases of strangulation (see later) and in some cases of incomplete obstruction. The distended small bowel has a characteristic appearance best seen on the supine x-ray. In the jejunum the distended valvulae conniventes stand out as a hoop-like or herringbone pattern (see fig. 28) while the ileum has a much smoother, more flattened appearance. These radiological findings make it possible to define the level of obstruction in some cases. The distended small bowel may take up a characteristic transverse loop arrangement on the supine film (see Fig. 28). This corresponds to the clinical physical sign of "step laddering" which is occasionally seen in the thin patient. In the series of small bowel obstruction due to simple adhesions, gaseous distention was identified in 80% of the cases, the diagnosis of obstruction still being possible in the two cases without gaseous distention because of air fluid levels. It is interesting that the two cases without gaseous distention showed multiple fluid levels, some of which were long and in neither case were hoops seen on the erect films. It would seem, therefore, that it is the relatively longstanding obstruction which shows no gas (and long fluid levels) and not the early obstructions. The gaseous distention produced a transverse loop

arrangement in 60% of the cases of simple adhesive obstruction.

Air Fluid Levels

These are the characteristic signs of mechanical obstruction, but it must be remembered that they are not pathognomic of intestinal obstruction because of their occurrence in both the normal x-ray and in the presence of paralytic ileus. This subject has been studied in detail by Gammill and Nice (1972), who in a study of 300 normal cases found air fluid levels in only 14. In only three of these cases could the small bowel be considered to be abnormally dilated, i.e. to have a diameter greater than 2.5cms. In the cases with fluid levels present, the number varied from two to five and their length from 2 - 2.5cms. Most of these normal small bowel fluid levels were in the right iliac fossa. In the same series, from 1 - 10 fluid levels in the large bowel were present, varying in length from 1 - 10cms. It should also be remembered that enemas and certain drugs (e.g. narcotics) can produce air fluid levels on the erect x-rays. In the obstructed case the longer the period of obstruction the greater the number of fluid levels, and similarly, the lower the level of obstruction the greater the number of fluid levels. Again these facts are said to be useful in an attempt at location of the level of the obstruction.

The air fluid levels may appear on the erect x-rays as isolated fluid levels or as part of the hoop shape (inverted U - fig. 27) appearance which the bowel tends to take up. The fluid levels seen vary greatly in length depending on whether they represent a fluid level seen across the apex of a distended loop or whether they are an air fluid level in one of the limbs of the hoops mentioned above. In the early phase of a simple

obstruction, the air fluid levels are usually at a different height in the corresponding limbs of each hoop, indicative of over-active peristaltic activity. When the obstruction becomes more prolonged and in paralytic ileus the air fluid levels tend to appear at the same height in the limbs of the hoop. From the results shown in Table 16 it can be seen that air fluid levels were present in all 10 cases of simple adhesive obstruction, i.e. the air fluid level is the most accurate diagnostic feature. In this series there was no direct relationship between the number of air fluid levels and the height of the obstruction but unfortunately I did not record the length of time of the obstructive process, the other factor which would be involved in this. Hoop arrangement of the small bowel was seen in seven of the 10 cases and it is interesting to note that the cases with the most number of hoops had the levels in the limb at the same height and also had the longer air fluid levels. This is undoubtedly an indication that the active hyperperistaltic stage of the obstruction is changing to the more parietic stage, i.e. this is a later stage in the acute obstruction process.

The String of Beads Sign

This sign was described by Frimann-Dahl (1960) in the second edition of his book "Roentgen Examination in Acute Abdominal Diseases". However, the author notes that the sign is not commented upon in the third edition of the book, presumably because it is not considered to be specific. The sign is seen in both the erect and supine films if present and consists of a line of bubbles of gas which represent small amounts of gas trapped beneath the valvulae conniventes of the small bowel. The string of beads sign unfortunately is not pathognomonic of small bowel obstruction and can occur in

TABLE 16 SIMPLE ADHESIVE OBSTRUCTION - DETAILED RADIOLOGICAL FINDINGS (10 CASES)

DIAGNOSIS	GAS DISTENTION	AIR-FLUID LEVEL NUMBERS IN LENGTHS (cms)							LEVEL OF OBSTRUCTION (LOOP OUTLINE)	TRANSVERSE LOOPS	STRING OF BEADS	GAS STREAKS	PSEUDO TUMOUR	AIR-FLUID LEVELS IN HOOPS	EMPTY COLON	FREE FLUID
		AIR-FLUID LEVEL NUMBERS IN LENGTHS (cms)														
		7	6-7	5-6	4-5	3-4	2-3	2								
SINGLE ADHESION MID SMALL BOWEL	+			1	4			15	HIGH (JEJUNAL)	+	+	-	-	-	+	-
LOW ILEAL BAND	+					1	4	10	-	-	-	-	-	1	-	-
LOW ILEAL BAND	+				1	2	3	4	-	+	+	-	-	2	+	-
LOW MULTIPLE ADHESIONS	+	2	3	1	1			6	-	+	+	-	-	Same Ht. x 5	+	-
ADHESION 75cms FROM ILEO-CAECAI VALVE	+				1	3		10	-	+	+	-	-	1	+	-
LOW ADHESIONS	-	1		1	1	2		7	-	-	-	-	-	-	-	+
LOW ADHESIONS	+				1	2	2	6	-	+	-	-	-	1	-	-
ADHESIONS 100cms FROM ILEO-CAECAI VALVE	+	2	2	1	2			6	+	-	-	-	-	Same Ht. x 3	+	-
MID SMALL BOWEL ADHESIONS	-				4	2	2	8	-	-	-	-	-	-	+	-
LOW ADHESIONS	+				1	3	3	10	-	+	+	+	-	2	-	-

both normal x-rays and in other pathological conditions, e.g. gastroenteritis. In this series it was present in 10% of the overall cases of obstruction and in three out of 10 cases of the simple obstructions (30%). Even though non-specific, I think it is a sign which is helpful in confirming the diagnosis.

Gas Streaking or Positive Stretch Sign

This sign is described by Williams (1964) and is of the same derivation as the string of beads sign. In the supine position small or moderate amounts of gas will appear as parallel streaks in the line of the small intestine. Williams says that these gas streaks represent a reliable sign of distended intestine, because in a normal non-dilated intestine, a similar amount of gas would appear as a squarish, oval or circular radiolucency rather than as a parallel streak. Unfortunately, this sign did not appear with sufficient frequency in either the overall series or the simple adhesive obstructed series, to be of much value.

Emptying of the Post-Stenotic Bowel and Colon

In simple small bowel obstruction, the bowel in the post-stenotic region remains active, thus in the early films gas may be visible in the post-stenotic small bowel or colon while on later films the gas and faeces content tends to lessen in amount. This loss of colonic and small bowel content tends to highlight the obstructive loops. In this series of 10 cases of simple obstruction, the post-stenotic bowel was thought to be empty or relatively empty in six of the ten cases.

Free Peritoneal Fluid

The obstructed small bowel not only continues to secrete into its

lumen but also loses fluid as a transudate into the peritoneal cavity. This may be seen as free fluid in the pelvis on the erect film or as free fluid between the loops of bowel or in the flanks on the supine x-ray. The author did not find it to be of great importance in this series and it was identified in only one of the ten cases.

Identification of the Level of Obstruction

The aids to diagnosis of the level of obstruction in any case of simple obstruction are listed on page 57. In this series of cases it was possible to suggest the level of obstruction in only five cases with any certainty. In all of these five cases the configuration of the distended bowel enabled this to be done (i.e. it was the herringbone appearance of the jejunum or the smooth appearance of the ileum which enabled the level of obstruction to be identified). The author did not find the number of air fluid levels, the number of hoops or the pre-stenotic dilated loop to be of any great reliability in predicting the level of obstruction.

Strangulating Obstruction due to Extrinsic Lesions

The term "strangulation" is used to imply an interference with the blood supply of the bowel. For this to take place in the case of obstructed bowel, the lumen must be obstructed at two points, thus creating a loop of obstructed bowel. The loop may be closed, that is completely obstructed, or may be incompletely obstructed. The importance of diagnosing the presence of strangulation must be emphasised for the following reasons:

1. Although most cases of small bowel obstruction are treated by surgery, the presence or even suggestion of strangulation makes operation a matter of urgency.

2. The history and clinical signs do not always provide definitive evidence of small bowel strangulation. Furthermore, obstruction and strangulation of a loop of small bowel can occur in the absence of the classical small bowel radiological features, as is discussed in detail below.
3. If the presence of strangulation could be ruled out, many patients would benefit from conservative treatment - e.g. (a) poor risk patients unsuitable for general anaesthesia; (b) patients who have already had previous laparotomies for adhesive obstruction; (c) patients with an element of mechanical obstruction in addition to a paralytic ileus.

If the loop of bowel is incompletely strangulated, the radiological picture mimics that of simple small bowel obstruction and may not be distinguishable from it (Frimann-Dahl, 1974f), thus gaseous distention above the loop together with air fluid levels are present in the pre-stenotic loops. The stenosed loop itself may contain both air and fluid or may have the coffee bean appearance first described by Mellins and Rigler in 1954. If, however, the stenosed loop is completely closed then one of two radiological pictures may ensue: Firstly, there may be the typical picture of small bowel obstruction with gaseous distention and air fluid levels in the pre-stenotic loops. Secondly, in about 23% of cases, gas may be absent (Mellins and Rigler, 1954) and only very small scanty air fluid levels are present (Frimann-Dahl, 1974f). The basis of this finding is that the strangulating process causes a paresis of the proximal bowel, a physiological process which has been demonstrated in the animal by

Chesterman (1944). The closed loop itself produces fluid but not gas (Anderson and Ringsted, 1943) and therefore the air fluid level of the incomplete loop obstruction is also lost and strangulation is complete. The outcome of the above pathophysiological process is that in a percentage of strangulation obstructions, the normal radiological features of obstruction may be absent. In these cases, the signs described below become of the utmost importance:

1. The Coffee Bean Sign - If the strangulation is incomplete the stenosed loop may appear as the coffee bean sign. This sign was defined by Mellins and Rigler in 1954. It is due to the localised distention of the segments of adjacent limbs of the loop with gas. These gas-filled loops are separated by an inflamed oedematous thickened double layer of intestinal wall which gives the curve of the coffee bean (fig. 30).
2. The Pseudo-Tumour Sign - If the loop is completely obstructed (closed) the pseudo-tumour sign of Frimann-Dahl (1944) may be produced. The adjacent limbs of the closed loop are filled with fluid alone and appear on the x-ray as a soft tissue density usually with a lobulated outline (fig. 29).
3. The Fixed Loop - The presence of a fixed loop of bowel is shown by the fact that the abnormal loop of bowel remains in a constant position on the erect, the supine and the lateral films (figs. 32,33), (Mellins and Rigler, 1954).
4. The Loss of Mucosal Pattern - A strangulated closed loop of bowel loses the segmental markings associated with the valvulae conniventes

of the small bowel and becomes smooth and featureless in outline (Hunt, 1948; Lockwood et al., 1948).

In addition to the above signs a group of less specific signs have been defined. These should arouse the suspicion of a strangulation and promote a more careful search for the more specific features outlined above (Mellins and Rigler, 1954).

1. The absence of small intestinal gas in a patient suspected clinically of having a small bowel obstruction. This indicates the closed loop obstruction as defined above.
2. The presence of long fluid levels in the small intestine far beyond the normal size. These occur in the partially obstructed loop and are due to the loop being distended out of all proportion to the rest of the intestine.
3. The absence of decompression of a localised loop following naso-gastric suction indicating that the loop is closed.

In this series, only two cases of strangulation were present. Because of this lack of numbers, no comment can be made regarding the incidence of the signs outlined above. The two cases are, however, now described in full, because they illustrate the problems discussed above:

Case 1

This was a 44 year old lady with an adhesive loop obstruction. The presenting history was typical of small bowel obstruction with colicky abdominal pain and vomiting. The plain x-ray showed multiple small bowel fluid levels. No signs of a strangulating loop were present on the plain x-rays in either prospective or retrospective review.

Case 2

This was a 60 year old man who had had a laparotomy 20 years previously for perforated appendicitis. He gave a history of small bowel colic and vomiting and on examination had no distention, lower abdominal tenderness and rebound tenderness, and only scanty bowel sounds. The plain x-rays of the abdomen showed two small fluid levels (2 and 2.5cms in diameter), no gaseous distention and no other signs of small bowel obstruction, either strangulating or simple. At laparotomy he had a 6" loop of non-viable small bowel due to a band across the small bowel to the site of his appendicectomy.

These two case histories illustrate the problems of the diagnosis of the strangulated loop. One case had the signs of a simple obstruction and none of strangulation and the second case had virtually no signs at all. We must rely on the work of Mellins and Rigler (1954) and Frimann-Dahl (1944) for statistics as to the occurrence of the various combination of signs in strangulation. Mellins and Rigler studied a group of 26 patients shown at operation to have strangulating obstruction. The radiological findings of these 26 cases are shown in Table 17. In 60% of his cases a closed loop was demonstrable on the x-rays. A fixed portion of the small intestine was seen in 50% of cases and a loss of mucosal markings in 50% also. Three cases showed only the signs of simple obstruction and in one case mechanical obstruction could not be diagnosed at all (as in case 2 above).

The strangulating loop is, perhaps, one of the most interesting problems of the radiology of the acute abdomen. Little has been published in recent years and Mellins and Rigler's paper in 1954

TABLE 17

X-ray findings in 26 cases of Strangulating Obstruction

(Mellins and Rigler, 1954)

Closed loop	15
A. Gas distended (coffee bean sign)	7
B. Fluid filled (pseudo-tumour sign)	8
Fixation of loop	13
Loss of mucosal pattern	12
Absence of gas above obstruction	6
Presence of small amount of gas in colon	17

still remains the most detailed available. I have therefore set up a prospective investigation of this topic and would hope over the years to build my series of strangulating obstructions into a worthwhile group. From the figures in my series (even in the busy Leeds emergency system) this must obviously take time. Perhaps most important is that the cases will continue to be my own and will therefore be exactly documented, a feature which is lost when collected series of several surgeons' patients are used.

External Herniae

As can be seen from Table 14 and the results section, strangulated external herniae accounted for 22 of the 42 cases of small bowel obstruction (51%). This is in contrast to recently quoted figures from other sources. Cantor and Reynolds' review from an American source showed more than half their cases to be due to adhesions and Thomas's report from Australia (1968) found that post-operative adhesions were responsible for 52% of their cases of small bowel obstruction and external herniae only 37%. It is impossible to explain why there should have been such a high incidence of obstructed herniae in this series; in the second part of the thesis when a consecutive series of acute abdomens were being examined when admitted to Casualty, the incidence of small bowel obstruction as compared to strangulated external herniae was much more in accordance with the other figures which have been quoted above. It may therefore just have been an isolated incidence of one type of cause occurring rather more frequently than usual. The breakdown of the series of external herniae into their relative types was -

inguinal	10
femoral	8
umbilical	2
incisional	2

This distribution agrees with Jones's comment (1974c) who states "as a consequence of a different liability to strangulation, about equal numbers of strangulated femoral and inguinal herniae are seen".

Radiological Signs

All our cases of strangulated external hernia showed air fluid levels; only in one case were air fluid levels actually identified outside the peritoneum, because no special views of that area were taken routinely. In several cases the air fluid levels pointed down to the groin involved. There was no correlation between any of the different types of hernia and the x-ray picture produced, i.e. no special incidence of numbers or air fluid levels, string of beads signs or gas streaking signs. In the one case of a Richter's hernia in the series (a femoral hernia) the x-ray pictures were of a small bowel obstruction. Those cases of inguinal hernia in the series all had small bowel in the hernial sac at operation. Those cases of femoral herniae included either small bowel or omentum, the clinical picture of small bowel obstruction being the same in both cases.

Gall Stone Ileus

This series of 42 cases of small bowel obstruction included one case of gall stone ileus, giving an incidence of 2.4%. This would agree with the incidence of 2% quoted by Rigler et al. (1941) and of 3% quoted by Jones (1974d). It must be remembered that most cases of gall stone ileus occur in obese elderly females, and that according to Vick's figures

(quoted by Brockis and Gilbert, 1950) gall stone ileus is responsible for 23.7% of all small bowel obstructions over the age of 70 years.

Gall stone ileus is a difficult clinical diagnosis to make - reflected in the fact that the mortality rate is still about 25% (Jones, 1974b). This seems to emphasise the importance of the plain abdominal x-ray.

Rigler et al. (1941) described four signs in the plain abdominal x-ray as indicative of gall stone ileus. These are:

1. The presence of gas in the bile duct.
2. The presence of a radio opaque gall stone.
3. The presence of signs of small bowel obstruction with gaseous distention and small bowel fluid levels.
4. The absence of a gall stone (or stones) noted at a previous examination.

The incidence figures for these criteria differ from series to series (Rigler, 1941; Brockis and Gilbert, 1950; Anderson and Zederfelt, 1969; Frimann-Dahl, 1974g) but may be summarised as follows:

1. Gas in the biliary tree probably does not occur in greater than one third of cases and the incidence may not even be as high as this.
2. Radio opaque gall stones are not seen in more than 50% of cases (because of a low calcium content or because they are lost against other bony structures).
3. Air fluid levels probably occur in most cases but may be short and few in number with little gaseous distention (because of the intermittency of the condition).
4. It is unusual for a gall stone to have been previously demonstrated and then lost on the acute films.

Two case histories are described now from the author's own experience which illustrate the above clinical and radiological findings.

Case 1

Mrs. F, aged 69 years (this was the case of gall stone ileus included in the small bowel series). This lady was admitted as an emergency with a history of colicky abdominal pain and vomiting. On close questioning she admitted to previous intermittent bouts of abdominal pain and vomiting for a ten day period. On examination the patient was dehydrated and ill. Examination of the abdomen showed it to be distended with high pitched bowel sounds. Plain abdominal x-rays showed (1) air fluid levels, (2) gas in the biliary tree, and (3) a radio opaque calculus (fig. 10).

Case 2

A patient presented at the Out-Patient Clinic with a three month history of intermittent abdominal pain and diarrhoea. Sigmoidoscopy was normal. A barium enema was ordered and showed a choledochocolic fistula (fig. 75). No gall stone was demonstrated on the x-ray and at subsequent laparotomy there was no evidence of any remaining gall stones in either the bowel or gall bladder or of any other disease apart from the fistula.

This latter case illustrates the point that many people probably pass their gall stones without ever coming to hospital. The true incidence of gall stone intestinal fistulae and of gall stone ileus is probably therefore not known.

Food Bolus Obstruction

This is a relatively rare form of obstruction, no instance having been seen in this series. Many foods have been implicated in this condition. Stephens (1962) quotes 61 different varieties as having been implicated.

Clinically, food bolus obstruction should be particularly suspected in two groups of patients presenting with intestinal colic and the plain x-ray picture of small bowel obstruction: those who are dentureless and therefore chew their food poorly, and secondly in patients who have previously had a partial gastrectomy (Ward-McQuaid, 1950). No special features are seen on the plain x-rays other than the typical signs of small bowel obstruction described previously.

Case History

The author recently encountered one case of food bolus obstruction in a 13 year old boy who was found to have food bolus obstruction due to eating unripe apples. This occurred ten days after a Meckel's diverticulectomy and therefore had a second pre-disposing factor. The plain abdominal x-rays showed a low small bowel obstruction. At operation the impacted food bolus was milked through a reasonably wide section of terminal ileus at site of the resection of the Meckel's diverticulum. No enterotomy had therefore to be performed and the boy made a straightforward recovery.

CHAPTER 5INTESTINAL OBSTRUCTIONPart 2: Large Bowel Obstruction

INTRODUCTION

The causes of acute obstruction of the large bowel can be classified into two groups, those with mechanical obstruction of the lumen and those with an open lumen (Table 18). In the author's series of cases, mechanical obstruction of the lumen was caused by only three pathologies - carcinoma, volvulus and intussusception, and it is, therefore, proposed to limit the discussion to these three entities. In the second group (Table 18) examples of toxic dilatation, mesenteric thrombosis and intestinal pseudo-obstruction were encountered and thus a short section on these three pathologies is also included.

TABLE 18

CAUSES OF ACUTE LARGE BOWEL OBSTRUCTION

A. MECHANICAL OCCLUSION OF THE LUMEN

Intrinsic Lesion

1. Neoplastic - carcinoma, sarcoma
2. Inflammatory - diverticulitis, lymphogranuloma, ulcerative and granulomatous colitis
3. Miscellaneous - intussusception, radiation strictures, pneumatosis intestinales, volvulus

Obturator obstruction

Gallstones

Bezoar

Foreign body

Enterolith

Faecal impaction

Extracolonic Lesions

Adhesions and bands

Herniae

Compression by extra-intestinal mass of tumour

Pregnancy

B. ACUTE OBSTRUCTION WITH OPEN LUMEN

Toxic megacolon

Intestinal pseudo-obstruction

Mesenteric thrombosis

ACUTE INTESTINAL OBSTRUCTION DUE TO CARCINOMA OF THE LARGE BOWEL

INTRODUCTION

Carcinoma of the colon accounts for about 20 per cent of all cases of intestinal obstruction (Vick, 1932). Some 30 per cent of all neoplasm of the large intestine present with acute intestinal obstruction and of this group the lesion is on the right side in 30 percent and on the left side in 70 per cent (Goligher and Smiddy, 1957). The classical clinical history of abdominal pain, abdominal distention and constipation with vomiting as a late feature, is the basis for diagnosis of the left sided tumours while the obstructing lesions of the right side of the colon tend to present with vomiting as an earlier feature, because of incompetence of the ileo-caecal valve.

MATERIALS AND METHODS

Over a period of 4 years in the Leeds Area Group of Hospitals, each patient admitted with suspected acute, large bowel obstruction received a routine chest x-ray and erect and supine abdominal x-rays. The diagnosis of obstructing carcinoma of the colon was not accepted unless confirmed at operation.

A record of the site of the obstructing lesion was kept and the radiographs reviewed retrospectively for the radiological features of internal obstruction outlined below:

Radiological signs of large bowel obstruction due to carcinoma

Gas and fluid accumulate in the prestenotic portion of the large bowel, just as in small bowel obstruction. The gaseous distention is seen

on the supine x-ray and the fluid levels on the erect film. Three basic radiological patterns of obstruction occur, depending on the state of competence of the ileo-caecal valve (Love, 1973).

Type IA (fig. 39)

In this case, the ileo-caecal valve is closed and competent. The colon is dilated down to the point of obstruction with the caecum showing the greatest degree of dilatation. There is little or no small bowel distention.

Type IB (fig. 40)

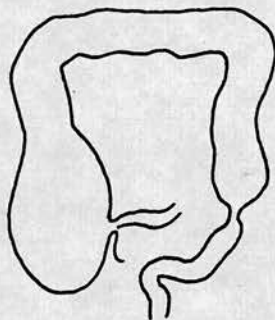
Again the ileo-caecal valve is competent, the caecum and large bowel are distended from the point of obstruction, but the small bowel is also distended proximal to the closed ileo-caecal valve.

Type II (fig. 41)

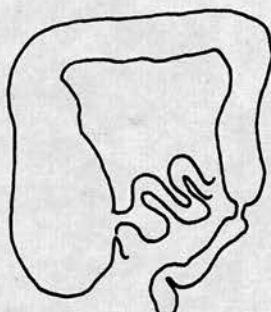
In this case, the ileo-caecal valve is incompetent. Distention of the large bowel to the level of the lesion occurs, but the caecum is not distended. The small bowel is distended by back pressure of the bowel contents through the open ileo-caecal valve.

The obstructing lesion itself may occasionally be outlined by gas contained within the lesion and proximal to it.

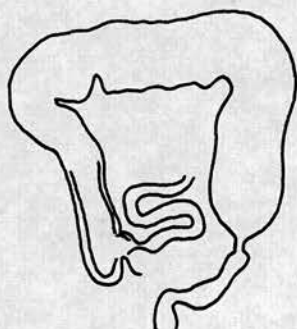
Diagrammatic illustrations of the three configurations of large bowel obstruction are shown on the next page:

TYPE IA - LARGE BOWEL OBSTRUCTION

1. Competent ileo-caecal valve.
2. Large thin walled dilated caecum.
3. Dilated large bowel to level of lesion.
4. No small bowel distention.

TYPE IB - LARGE BOWEL OBSTRUCTION

1. Competent ileo-caecal valve.
2. Large thin walled dilated caecum.
3. Dilated large bowel to level of lesion.
4. Small bowel distention proximal to closed I-C valve.

TYPE II - LARGE BOWEL OBSTRUCTION

1. Incompetent ileo-caecal valve.
2. Thick walled, non-dilated caecum.
3. Dilated large bowel to level of lesion.
4. Small bowel distention proximal to open ileo-caecal valve.

RESULTS

Twenty-eight obstructing carcinomas of the large bowel were included in the study. The anatomical site of these tumours is shown in Table 19. Five of the tumours (18 per cent) lay on the right side of the colon and the remaining 23 (82 per cent) on the left side. In both cases of carcinoma of the caecum, the radiological picture was that of a low small bowel obstruction. In one of these cases, a right iliac fossa soft tissue mass could be identified.

In the case of the hepatic flexure carcinoma the caecum was distended and the small bowel dilated, giving a Type IB radiological configuration.

The radiological configuration of the remaining 25 cases is shown in Table 20. In 8 per cent of the cases the ileo-caecal valve was competent with a distended caecum and large bowel but no evidence of small bowel dilatation (Type IA). In 67 per cent of the cases, the caecum and large bowel was distended and the small bowel dilated proximal to a competent ileo-caecal valve (Type IB). In the remaining 25 per cent of cases, the configuration was that of Type II with a distended large and small bowel but no caecal distention, indicating competence of the ileo-caecal valve.

In none of these 28 cases was the tumour identifiable by gaseous outline.

TABLE 19

ANATOMICAL SITE OF 28 CASES OF OBSTRUCTING CARCINOMA OF THE COLON

ANATOMICAL SITE	NO OF CASES	%
CAECUM	2	7
ASCENDING COLON	2	7
HEPATIC FLEXURE	1	3.5
TRANSVERSE COLON	2	7
SPLENIC FLEXURE	3	10.5
DESCENDING COLON	2	7
SIGMOID COLON	16	58

TABLE 20

LARGE BOWEL OBSTRUCTION DUE TO CARCINOMA

RADIOLOGICAL SIGNS - 25 CASES

RADIOLOGICAL SIGN	No	%
1. DISTENDED CAECUM AND LARGE BOWEL WITH COMPETENT ILEO-CAECAL VALVE (TYPE IA)	2	8
2. DISTENDED CAECUM AND LARGE BOWEL WITH SECONDARY OBSTRUCTION OF SMALL BOWEL DUE TO COMPETENT ILEO-CAECAL VALVE (TYPE IB)	17	70
3. DISTENDED LARGE BOWEL WITH NO CAECAL DISTENTION AND INCOMPETENT ILEO-CAECAL VALVE (TYPE II)	6	25 22

DISCUSSION

From the clinical point of view, this small series confirmed that the majority of carcinomas of the large bowel which present with acute intestinal obstruction, occur in the left side of the colon. This is for two reasons - firstly, the overall incidence of left sided carcinomas is greater (Goligher, 1975) and secondly, the left sided tumours are of the stenosing type rather than the ulcerating, cauliflower type found more often on the right side.

From the radiological point of view several interesting facts emerged from this series:

- a) In this series, diverticulitis of the colon was not found to present with a radiological picture mimicking an obstructing carcinoma of the large bowel. This is in contrast to the American series who report up to 40 per cent of their large bowel obstructions as being due to diverticulitis (Botsford, 1967; Byrne, 1968).
- b) Except in the two cases of carcinoma of the caecum, which presented with the picture of low small bowel obstruction, no difficulty in making the diagnosis of large bowel obstruction was encountered. Thus in all of the remaining 26 cases, evidence of large bowel distention was found on the x-rays, making the correct diagnosis possible. However, it was found to be difficult to predict the exact site of the obstruction. Unfortunately, in the early part of the series records were not kept of the predicted site of the obstruction in all of these cases, and, therefore, absolute figures cannot be quoted. However, in about one quarter of the cases an obstructing lesion more proximal than that actually found at operation was predicted pre-operatively. The reason for this is given by Primann-Dahl (1974h), who

suggests that because the left side of the colon is more muscular, the gaseous distention occurs much later than that on the right of the colon. In other words, in the case of carcinoma of the sigmoid, although the caecum and more proximal part of the colon may be very distended, the sigmoid is the last part to dilate. The obstructive lesion may, therefore, appear to be higher than in the case.

c) The state of competence of the ileo-caecal valve would appear to be responsible for the radiological picture which develops. In the 25 cases of tumours distal to the hepatic flexure in this series, it was possible to classify the radiological picture as one of the three types described by Love (1973). The incidence of the three types in this series were comparable to Love's own experience, the majority being classified as Type IB. From the practical point of view, types IA and IB require more urgent decompression of the bowel, because of the risk of caecal perforation. In the type II obstruction the degree of small bowel obstruction seen radiologically was greater than that of the Type IB obstruction, so much so that in several cases, there was a difficulty in deciding how much of the large bowel was distended because of the 'obliterating' effect of the distended small bowel.

d) The x-ray films in this series indicated that the longer the period of absolute obstruction, the greater the degree of gaseous distention and the longer the fluid levels seen on the erect film.

CONCLUSIONS

1. The obstructing lesion in 28 cases of carcinoma of the colon was found on the left side in 82 per cent of the cases and on the right side in 18 per cent.

2. The diagnosis of large bowel obstruction was possible from the plain x-rays in all 26 of the cases distal to the caecum but it was not always possible to predict the exact site of obstruction pre-operatively.
3. The x-ray appearances were dependent on the state of the ileo-caecal valve and were classifiable as one of three types.
4. In this series, the actual outline of the obstructing lesion was not found to be visible on the x-ray films.

ACUTE INTESTINAL OBSTRUCTION DUE TO VOLVULUS OF THE LARGE BOWEL

The overall incidence of volvulus of the large bowel in the U.S.A. and United Kingdom is quoted as 1.3 - 1.6 per cent of all cases of intestinal obstruction (Wangensteen, 1955; Vick, 1932). The incidence in other parts of the world is much higher - for instance it is calculated that the incidence of volvulus in Uganda is ten times that in the United Kingdom (Hall Craggs, 1960). During the three year period in which the 28 cases of carcinomatous large bowel obstruction was studied, 2 cases of sigmoid volvulus and 1 case of caecal volvulus were treated. The radiological features which occur in large bowel volvulus are discussed below with reference to the cases included in this series:

Sigmoid Volvulus

Radiological Features

1. Gaseous distention of the sigmoid loop, extending vertically from the pelvis to the liver or diaphragm (Rigler and Lipschultz, 1940).
2. Relatively slight gaseous distention of the remainder of the large bowel (Rigler and Lipschultz, 1940).
3. Wide fluid levels are seen in both limbs of the twisted loop on the erect abdomen film.
4. In the supine film, three radio-dense lines converging on the apex of the volvulus are seen (Frimann-Dahl, 1974i). These are formed by the walls of the large bowel (fig. 42).
5. Perforation of the twisted loop may occur giving subdiaphragmatic gas (Frimann-Dahl, 1974i).

The plain x-rays of the first case of sigmoid volvulus included in this series were 'classical' in that the apex of the volvulus was in the lower part of the film, with little or no distention of the rest of the large bowel. In the second case, however, the apex lay towards the left upper quadrant of the abdomen, with the distended loop pointing vertically downwards. In this case there was marked distention of the rest of the large bowel.

In neither case had perforation occurred.

Caecal Volvulus

Radiological features

1. The outline of the gas distended caecum appears as an oval or kidney shape filling most of the abdominal x-ray, and extending to both sides of the abdomen (fig. 43).
2. A single broad fluid level is seen across the caecum on the erect film.
3. The slightly distended small bowel is seen at the apex of the volvulus, usually arranged like the fingers of a hand.

The only case of caecal volvulus encountered in this series had a classical x-ray appearance.

ACUTE OBSTRUCTION OF THE LARGE BOWEL WITH OPEN LUMEN

Three causes of 'large bowel obstruction' with an open lumen were encountered in this series:

- toxic megacolon (2 cases)
- intestinal pseudo-obstruction (2 cases)
- mesenteric thrombosis (4 cases)

The radiological appearances are discussed and illustrated below; no conclusion, however, as to the incidence of the features can be drawn because of the lack of numbers.

(1) Toxic Megacolon (Toxic Dilatation)

Toxic dilatation is one of the complications of ulcerative colitis, it is said to occur in about 11 per cent of all severe cases of ulcerative colitis (Goligher, Hoffman and de Dombal, 1970). The transverse colon is almost always involved, the operative findings being those of mucosal loss and thinning of the muscular wall of the colon. The most reliable method of diagnosis is the plain abdominal x-ray the following features being found:-

1. Gaseous distention, particularly of the transverse colon but also involving the ascending, descending and sigmoid colon to a variable extent. This is best seen on the supine x-ray.
2. Long fluid levels are seen in the dilated colon on the erect films.
3. Thinning of the colon wall with loss of haustrations, serrated edges and a pseudo-polypoid pattern of the mucosa.
4. Usually there is no solid faecal content visible in the large bowel.
5. If perforation has occurred, some subdiaphragmatic gas may be seen.

The x-rays from both cases of toxic dilatation included in this series are shown as figures 45 and 46. In figure 45, there is complete loss of the haustrations in the descending and sigmoid colon, indicating that the disease is most severe in these parts. In this case, no pseudopolyps were visible. In the case illustrated in figure 46, the transverse colon is the segment most affected and islands of mucosa (pseudopolyps) are best seen in the left side of the transverse colon.

(2) Intestinal pseudo-obstruction (colonic ileus)(fig. 47)

In this condition, the patient presents with the typical clinical history, clinical examination and x-ray findings of a large bowel obstruction and yet at laparotomy no obstructive lesion is found. The author has managed two such cases and it is most disconcerting at laparotomy to find no cause for the obstruction. In both cases, a caecostomy was performed, the patient settled and no lesion was identified on subsequent barium examinations.

The suggested underlying pathologies are:

- (a) Systemic infection (Morton, 1960)
- (b) Abdominal operations (Robertson et al., 1958; Morton, 1960)
- (c) Acute cholecystitis (Caves and Crockard, 1970)
- (d) Myocardial infarction (Jones, 1974e)
- (e) Antecedent episode of hypotension and hypoxia (Dudley et al., 1958)
- (f) Renal failure (Stephens, 1962)
- (g) Unknown aetiology

Both the cases in this series fell into the last category.

Intussusception

Four anatomical variations of intussusception occur, the approximate incidence of each type (Bailey, 1959) being shown below:

1. ileo-ileal	8%
2. ileo-colic	36%
3. ileo-caecal	46%
4. colo-colic	10%

90 - 95% of all acute intussusceptions occur in children (Shepherd, 1968^b) the majority of these being termed primary or idiopathic because the underlying aetiology is uncertain. In the adult cases, a tumour or polyp is usually found to have acted as the apex of the intussusception. In this series of intestinal obstruction, only two cases of intussusception were encountered - this low incidence (the usual incidence is 10% of all obstructions, Frimann-Dahl, 1974^j) is because the author was rarely involved with the treatment of paediatric emergencies. The two cases do however illustrate many of the plain x-ray features of intussusception, and are therefore described in full.

Plain x-ray features of Intussusception

1. Air/fluid levels due to obstruction of the bowel proximal to the site of intussusception.
2. Absence of gas in the hepatic flexure, possibly with the presence of small intestinal loops in the usual position of the intussuscepted colon (Castronovo, 1929).
3. The presence of a sausage shaped radiodense mass representing the intussuscepted intestine, which may or may not be surrounded by an air filled sheath (Schatzki, 1939).

Case 1

An 18 year old female was admitted to the Bradford Royal Infirmary with colicky lower abdominal pain and vomiting. She had previously had a small bowel resection for intussusception and was known to suffer from multiple polyposis (Peutz-Jegher Syndrome). On examination she had brown pigmentation of the buccal mucosa. Examination of the abdomen showed distention with tenderness in the right iliac fossa and the suggestion of a mass in that position. Plain x-ray of the abdomen confirmed the presence of an intussusception.

Plain x-ray (fig. 36)

The intussuscepted mass is well seen in the right iliac fossa with the double cylinder of air, lying with the intussusceptum and between it and the intussusciens.

At operation the patient was found to have an ileo-caecal intussusception with a further polyp acting as the apex.

Case 2

A 16 month old child was admitted to Bradford St. Luke's Hospital with an 8 hours history of intermittent screaming attacks. On examination the child showed extreme pallor, had an easily palpable 3cm mass in the right upper quadrant but had no red current jelly stool.

A clinical diagnosis of intussusception was made and confirmed by plain x-ray and barium enema.

Plain x-ray (fig. 37)

This showed a radiodense mass in the right upper quadrant with gas visible in the transverse colon. There were no fluid levels.

Barium enema (fig. 38)

This confirmed the presence of the intussusception in the right upper quadrant.

An ileo-colic intussusception was successfully reduced at laparotomy.

Mesenteric Vascular Occlusion

The vascular occlusion responsible for this syndrome may be of the superior mesenteric artery or vein; most often it is the artery which is implicated, the occlusion being due to thrombosis and only rarely an embolus. Although not a common surgical emergency (Mavor, 1962 reported 71 cases over an eight year period) the presentation of such a case is well recognised in presenting problems of diagnosis. The patient is usually over 50 years of age and presents with severe abdominal pain seemingly in excess of the accompanying abdominal signs. Often the patient is found to have an inoperable total mid-gut infarction by the time laparotomy is performed. For this reason any aid to diagnosis from the radiographs is very important.

The following plain radiograph signs are reported:

1. Absence of the normal amount of gas in the small intestine - this sign is said to be present early in the presentation, (Shaw and Rutledge, 1957).
2. Presence of small fluid levels in the small bowel suggestive of mechanical obstruction - a sudden increase in the number and size of these fluid levels may occur - in contradistinction to mechanical obstruction when these changes occur slowly (Frimann-Dahl, 1974k)
3. When the disease process is more advanced with established peritonitis the small bowel loops show marked distention with an irregular mucosa (Frimann-Dahl, 1974). Scott et al. (1971) describe thickened oedematous mucosa with gas as the bowel content, thickened oedematous mucosa with fluid content in the bowel and "thumb-printing" due to submucosal haemorrhage.
4. Gas may be present in the wall of the intestine - usually crescentic in shape (Schorr, 1963; Rigler and Pogue, 1965).

5. Gas may be seen in the portal venous radicles of the liver at a very late stage in the process of intestinal infarction (Wiot and Felson, 1961; Scott et al., 1971).

During the period of this study, 4 cases of mesenteric thrombosis have been seen by the author. The diagnosis in each case was confirmed at laparotomy; in all cases the extent of the infarction was found to preclude any definitive treatment.

Review of the plain radiographs showed the presence of small bowel fluid levels in each of the four cases (fig. 44). In one case only was portal venous gas identified (fig. 48); none of the other radiographic signs described above were identified either prospectively or retrospectively. These findings are in agreement with the comments of Ottinger and Austen (1967) who found the plain radiographs to be of limited use in the diagnosis of the condition, except in the terminal stage of the disease if portal venous gas were present.

PART II

SHOULD PLAIN ABDOMINAL X-RAYS BE
PERFORMED ROUTINELY IN THE ACUTE ABDOMEN?

Introduction

In the first chapter of his book 'Surgery of the Acute Abdomen', John Shephard (1968c) makes the following comments:

"There is considerable reluctance on the part of many surgeons to make full use of radiography in the acute abdomen and many surgeons consider that radiographic examinations are of limited value as an aid to diagnosis of an acute abdomen. Such objections must be examined and an attempt made to assess the true value of radiography."

Although it is apparent from the succeeding chapters of his book that Shephard places much importance on abdominal x-rays, he does not answer the question he asked. A search of the literature has failed to produce any quantitative information on the value of the plain abdominal x-ray as a routine investigation in the acute abdomen. This second part of the thesis was designed, therefore, to make a quantitative analysis of the plain abdominal x-ray and to assess whether it should become a routine examination in all cases of the acute abdomen.

Method

For a period of four months from January 1972 to June 1972 every patient admitted to the Leeds General Infirmary with a suspected acute abdominal disease was subjected to a routine series of x-rays carried out in the Accident and Emergency Department X-ray Unit. There were two exceptions to this rule:

- (1) those patients of child bearing age who admitted on direct questioning that they might be pregnant and in who there was no absolute indication for x-ray.
- (2) those patients who were considered to be too ill to undergo the routine radiography.

The routine radiography performed was an erect chest x-ray, and an erect and supine abdominal x-ray. In certain cases, a lateral decubitus film was included, either in addition to, or instead of, the erect abdominal film. All the films were taken in the Casualty X-ray Department by radiographers employed in the Casualty Department.

Prior to the x-ray examination each patient had a full clinical history taken by a member of the Accident and Emergency Department junior staff before being fully examined. Details of the history and examination were recorded on a standard sheet, specifically prepared for this purpose (Table 2.1) . A provisional diagnosis or differential diagnosis was made by the casualty officer and recorded at the foot of the history sheet.

Each of the patients entered into the study was followed up by the author and details of the patient's final diagnosis (made either at the admission or at a future out-patient follow-up or in-patient admission) were recorded separately.

Following the patient's discharge, the plain abdominal films were filed in the Accident and Emergency Department. Each set of films, together with the appropriate history sheet was allocated a number and the series was subsequently reviewed by a senior registrar radiologist. At this stage, the clinical information available to the radiologist consisted of a full history

UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

NAME..... AGE..... DATE.....

DURATION OF SYMPTOMS Hours..... Days.....

FIRST SYMPTOMS Pain. Vomiting. Diarrhoea. Nausea. Anorexia. Headache.

TYPE OF PAIN Colicky. Inflammatory. Constant. Varying. Intermittent.

SEVERITY OF PAIN 0. 1. 2. 3. 4.

LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L. Loin.

ONSET Hypochondrium. Back.

RADIATION OF PAIN .. R/L.I.F. Back. R/L. Loin. Shoulder Tip. Generalised.

VOMITING Absent. Before/After pain. Small. Medium. Profuse. Blood. Coffee Grounds. Bile. Faecal.

NAUSEA Absent. Present.

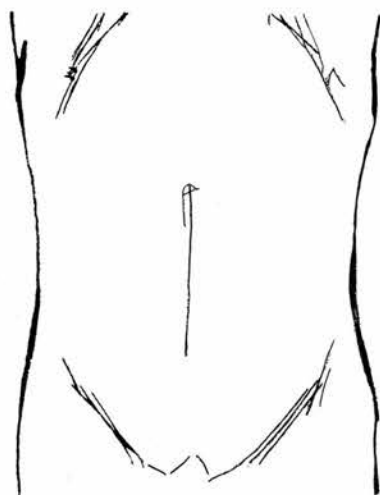
ANOREXIA Absent. Complete. Partial.

BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute.....days. Flatus.

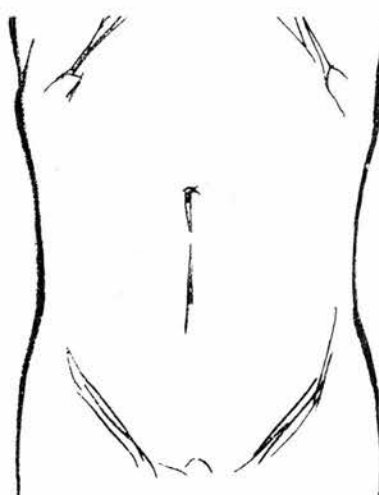
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.

MENSTRUATION Normal. Recent irregularity.

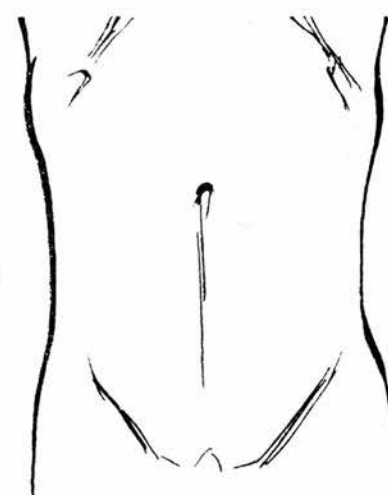
TENDERNESS.



RIGIDITY.



TUMOUR.



Hyper
aesthesia

T. P. R.
FACIES Anxious. Nervous. Flushed. Grey. Nil of note.

ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.

RECTAL EXAMINATION .. Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.

VAGINAL EXAMINATION .. Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.

CERVICAL GLANDS.. .. R/L. Large. Medium. Small. Tender/Not Tender.

RECEIVING ROOM DIAGNOSIS

OPERATION DIAGNOSIS (from Ward).....

and clinical examination, together with the casualty officer's diagnosis or differential diagnosis. A full radiologist's report for each set of x-ray films was recorded on the back of the clinical history sheet.

These were similar in length and type to those made on routine departmental reporting. At the completion of the series, the final diagnosis of each patient was compared to the radiologist's report. The radiologist's report was classified as either:

- (1) diagnostic
- (2) contributory to diagnosis but non-diagnostic
- (3) non-contributory to diagnosis
- (4) incorrect diagnosis

Results

In Table 22, the final diagnosis in 249 consecutive acute abdominal admissions to the Leeds General Infirmary are recorded. Eight patients were excluded from the series, 2 because of their poor general condition and 6 because of the risk of pregnancy.

In Table 23, the author's assessment of the radiologist's report for each set of X-rays is shown. It was considered that in 24% of cases the X-rays were diagnostic and that in a further 18% of cases, although not diagnostic they made a contribution to the correct diagnosis. Thus in 104 of the 249 cases studied (42%) the radiographs were of value to the clinician in making a correct diagnosis. In 57% of cases the radiographs were considered to have been unhelpful in making the diagnosis, but in only 1% was an incorrect diagnosis suggested by the radiologist.

TABLE 22

FINAL DIAGNOSIS IN 249 CASES OF THE ACUTE ABDOMEN

Diagnosis	No of Cases	Diagnosis	No of Cases
Urinary Tract Infection	7	Carcinoma of Caecum	2
Empyema of Gall Bladder	2	Carcinoma of Colon with Obstruction	5
Diverticulitis	5	Renal Colic	5
Acute Pancreatitis	11	Obstructed Umbilical Hernia	1
Fractured Pelvis	1	Constipation	5
Exacerbation of Duodenal Ulcer	6	Obstructed incisional Hernia	1
Acute Appendicitis	31	Mesenteric Adenitis	15
Perforated Duodenal Ulcer	11	Carcinoma of Pancreas	1
Pyloric Stenosis	1	Acute Pyelonephritis	1
Sigmoid Volvulus	1	Biliary Colic	4
Small Bowel Obstruction	18	Pneumonia	1
Intussusception	3	Toxic Dilatation of Ulcerative Colitis	1
Ruptured Ovarian Cyst	4	Gall Stone Ileus	1
Salpingitis	1	Enlarged Lymph Gland of Groin	1
Irreducible Inguinal Hernia	6	Gastroenteritis	2
Irreducible Femoral Hernia	5	Crohn's Disease	1
Acute Cholecystitis	24	Perforated Stump Abscess of Appendix	1
Carcinomatosis	5	Ileostomy Dysfunction	2
Abdominal Stab Wounds	3	Splenic Cyst	1
Leaking Aortic Aneurism	5	Neurogenic Pain	1
Twisted Ovarian Cyst	3	Meconium Ileus	1
Non Special Abdominal Pain	35	Bladder Stone	1
Perforated Oesophagus	1	Ruptured Diaphragm	1
Subacute small bowel Obstruction	2		

TABLE 23

RADIOLOGIST'S ASSESSMENT COMPARED TO
FINAL DIAGNOSIS IN 249 CASES OF THE ACUTE ABDOMEN

Assessment	No of Cases	Percentage
Diagnostic	59	24
Contributory to Diagnosis but Non-Diagnostic	45	18
Non Contributory to Diagnosis	143	57
Incorrect Diagnosis	2	1

Tables 24 to 26 show a detailed analysis of the three groups of cases (i.e. diagnostic, contributory and non-contributory). For each of the clinical conditions in each series a percentage is shown of the number of cases of each disease in which the x-ray was helpful.

Discussion

The organisation of the Accident and Emergency Department and the admission system at the General Infirmary at Leeds made it possible to carry out the study detailed above. The reasons for this are:

- (1) The General Infirmary Accident Department is the second busiest in the United Kingdom. In 1974 67,253 patients attended the Casualty Department of which 2,219 were admitted as general surgery emergencies. This enabled a large number of patients to be studied in the 4 month period of the trial.
- (2) All patients (irrespective of the suspected diagnosis) are seen by the Casualty Officer in the Accident and Emergency Department before admission to the hospital, there being no direct admission to the surgical units at the Leeds Infirmary. This enabled a consecutive series of all acute abdomens to be studied without any cases being lost because of direct admissions. Furthermore, because of the admission system, the organisation and follow-up of the trial was facilitated because there was only a single, central source of patients.
- (3) The general surgical registrar rotation at the Leeds Infirmary includes a six month, full-time attachment to the Accident and

TABLE 24

ANALYSIS OF 59 CASES IN WHICH
PLAIN X-RAYS WERE DIAGNOSTIC

Diagnosis	No of Cases Diagnostic	Total No of Cases	% Diagnostic
Fractured Pelvis	1	1	100
Perforated Duodenal Ulcer	6	11	55
Sigmoid Volvulus	1	1	100
Intussusception	1	3	33
Acute Cholecystitis	6	24	25
Carcinomatosis	2	5	40
Leaking Aortic Aneurism	4	5	80
Small Bowel Obstruction	17	18	95
Carcinoma of Caecum	1	2	50
Carcinoma of Large Bowel (except caecum)	5	5	100
Incisional Hernia	1	1	100
Acute Appendicitis	4	31	12
Ulcerative Colitis	1	1	100
Twisted Ovarian Cyst	1	3	33
Ileostomy Dysfunction	1	2	50
Splenic Cyst	1	1	100
Meconium Ileus	1	1	100
Bladder Stone	1	1	100
Ureteric Stone	1	5	20
Ruptured Oesophagus	1	1	100
Ruptured Diaphragm	1	1	100
Ruptured Ovarian Cyst	1	4	25

TABLE 25

ANALYSIS OF 104 CASES IN WHICH PLAIN ABDOMINAL X-RAYS
WERE EITHER DIAGNOSTIC OR OF HELP IN DIAGNOSIS

Diagnosis	No of Cases Helpful	No of Cases in Series	% Helpful
Diverticulitis	2	5	40
Fractured Pelvis	1	1	100
Acute Appendicitis	8	31	30
Perforated Duodenal Ulcer	6	11	55
Sigmoid Volvulus	1	1	100
Intussusception	2	3	66
Irreducible Inguinal Hernia	3	6	50
Carcinomatosis	4	5	80
Acute Cholecystitis	15	24	62
Leaking Aortic Aneurism	4	5	80
Ruptured Ovarian Cyst	1	4	25
Small Bowel Obstruction	17	18	95
Carcinoma of Caecum	2	2	100
Carcinoma of Large Bowel	5	5	100
Constipation	4	5	80
Incisional Hernia	1	1	100
Carcinoma of Pancreas	1	1	100
Biliary Colic	1	4	25
Acute Pancreatitis	7	12	58
Pneumonia	1	1	100
Ulcerative Colitis	1	1	100
Gall Stone Ileus	1	1	100
Twisted Ovarian Cyst	1	3	33
Subacute Small Bowel Obstruction	1	1	50
Stump Abscess of Appendix	1	1	100
Ileostomy Dysfunction	1	2	50
Gastro-Enteritis	1	2	50
Splenic Cyst	1	1	100
Neurogenic Pain	1	1	100
Abdominal Stab Wound	1	3	33
Meconium Ileus	1	1	100
Bladder Stone	1	1	100
Ureteric Stone	1	5	20
Ruptured Oesophagus	1	1	100
Irreducible Femoral Hernia	3	5	60
Ruptured Diaphragm	1	1	100

TABLE 26

ANALYSIS OF 143 CASES IN WHICH PLAIN ABDOMINAL X-RAYS
WERE OF NO HELP IN DIAGNOSIS

Diagnosis	No of Cases Non-Helpful	No of Cases in Series	% Non- Helpful
Urinary Tract Infection	7	7	100
Empyema of Gall Bladder	2	2	100
Exacerbation of Duodenal Ulcer	6	6	100
Acute Appendicitis	23	31	70
Twisted Ovarian Cyst	2	3	66
Ruptured Ovarian Cyst	3	4	75
Salpingitis	1	1	100
Pyloric Stenosis	1	1	100
Non-Specific Abdominal Pain	35	35	100
Irreducible Femoral Hernia	2	5	40
Abdominal Stab Wound	2	3	66
Acute Cholecystitis	9	24	38
Diverticulitis	3	5	60
Renal Colic	4	5	80
Umbilical Hernia	1	1	100
Subacute Intestinal Obstruction	1	2	50
Constipation	1	5	20
Perforated Duodenal Ulcer	5	11	45
Acute Pyelonephritis	1	1	100
Pancreatitis	5	12	42
Mesenteric Adenitis	15	15	100
Biliary Colic	3	4	75
Gland Right Groin	1	1	100
Inguinal Hernia	3	6	50
Gastroenteritis	1	2	50
Crohn's Disease	1	1	100
Carcinomatosis	1	5	20
Ileostomy Dysfunction	1	2	50
Intussusception	1	3	33
Leaking Aortic Aneurism	1	5	20
Small Bowel Obstruction	1	18	5

Emergency Department. The study was carried out by the author during this attachment. During the four month period of the trial all acute abdominal admissions to the hospital were examined by the author during his time on duty. Only during his off-duty periods were patients included in the series assessed by one of the other casualty officers. The Consultant in charge of the Accident Department, Mr. D.H. Wilson, encourages registrars to carry out research projects and time is set aside for this in the casualty officer's programme. The author used this time to complete the in-patient follow-up of patients included in the trial.

- (4) The Accident and Emergency Department at the Leeds Infirmary has its own radiology department, staffed day and night, which made it possible to x-ray the acute abdominal admissions at whatever hour of the day they presented.

If it was decided in casualty that a patient was to be admitted to the main hospital as a general surgical abdominal emergency, the patient was included in the trial. As will be seen from Table 22, the 249 cases included in the consecutive series included very few 'non-surgical' cases; for example few gynaecological or urological emergencies were admitted mistakenly to the general surgical wards. The reason for this is because the Infirmary Casualty Department has access to a resident medical officer (of registrar grade) in all specialities. Patients in whom the diagnosis is in doubt are initially investigated by the casualty officer and then referred to the appropriate registrar. All paediatric cases are assessed by the paediatric

medical and surgical staff and, apart from one case (of meconium ileus) the neonatal and abdominal paediatrics were therefore omitted from this series.

A satisfactory in-patient follow-up of the cases was attained by the author visiting the general surgical wards each day and recording any diagnosis made on the previous day (e.g. the operative diagnosis). If an immediate definite diagnosis was not made at this early stage, then a final diagnosis was established by reviewing the notes at discharge. If the patient was awaiting further investigation, the final diagnosis was taken from the out-patient follow-up notes. Thus the results for example of out-patient cholecystograms in suspected cases of acute cholecystitis and of barium meals in cases of epigastric pain, were used in the assessment of the final diagnosis. A definitive diagnosis was not made in all cases and these cases were classified as non-specific abdominal pain (NONSAP).

As the author knew the final diagnosis in many of the patients included in the series, it was decided that the x-ray films should be reported by a senior registrar radiologist who did not possess this information.

Because such a large number of patients and x-rays were involved, they were divided into groups of 25 sets of x-rays for each session of reporting. The history, examination and differential diagnosis were of greater detail than would normally be supplied on the much smaller x-ray request cards in use at the General Infirmary at Leeds. The radiologist emphasised that his reporting was made easier (and undoubtedly more accurate) by the detailed histories supplied.

Once the x-rays had been reported, the classification of the 'value' of the x-ray report was made at one session by the author and the radiologist

together. A simple 'scoring system' was chosen (i.e. diagnostic, contributory or non-contributory) because such a system is less open to individual interpretation or argument. Examples of individual cases, their appropriate x-ray reports and the classification of the x-ray report are now given:-

PATIENT 1

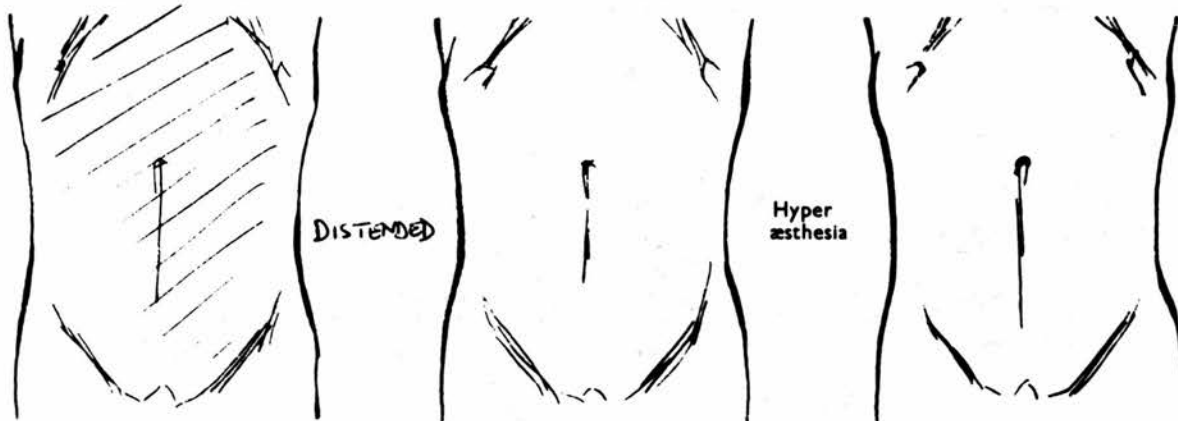
UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

NAME K.4 AGE 36 DATE 16/3/72
DURATION OF SYMPTOMS Hours 48 Days ..
FIRST SYMPTOMS Pain. Vomiting. Diarrhoea. Nausea. Anorexia. Headache.
TYPE OF PAIN Colicky. Inflammatory. Constant. Varying. Intermittent.
SEVERITY OF PAIN 0. 1. 2. 3. 4.
LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L. Loin.
ONSET Hypochondrium. Back.
RADIATION OF PAIN R/L.I.F. Back. R/L. Loin. Shoulder Tip. Generalised. Nil
VOMITING Absent. Before After pain Small. Medium. Profuse. Blood. Coffee Grounds. Bile.
Fæcal.
NAUSEA Absent. Present.
ANOREXIA Absent. Complete. Partial.
BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation Absolute 2 days.
Flatus.
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.
MENSTRUATION Normal. Recent irregularity.

TENDERNESS.

RIGIDITY.

TUMOUR.



T. P. R. High pitched bowel sounds
FACIES Anxious. Nervous. Flushed. Grey. Nil of note.
ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.
RECTAL EXAMINATION .. Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.
VAGINAL EXAMINATION .. Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.
CERVICAL GLANDS.. .. R/L. Large. Medium. Small. Tender/Not Tender.

RECEIVING ROOM DIAGNOSIS INTESTINAL OBSTRUCTION

OPERATION DIAGNOSIS (from Ward) FINAL DIAGNOSIS Sigmoid CARCINOMA

R.R.4

DIAGNOSTIC RADIOLOGY REPORT

PATIENT 1: K. G. 36 year old male.

HISTORY:)
 }
EXAMINATION: } see figure opposite

CASUALTY DIAGNOSIS: INTESTINAL OBSTRUCTION

RADIOLOGY REPORT: Chest x-ray: normal.

Abdominal x-rays (erect and supine): gaseous distention of
large bowel on supine film to level of mid sigmoid colon.
Gas/fluid levels in large bowel on erect film.
Appearances are those of an obstructing sigmoid lesion.

FINAL CLINICAL DIAGNOSIS: OBSTRUCTING SIGMOID CARCINOMA.

ASSESSMENT OF RADIOLOGY REPORT: DIAGNOSTIC

PATIENT 2

UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

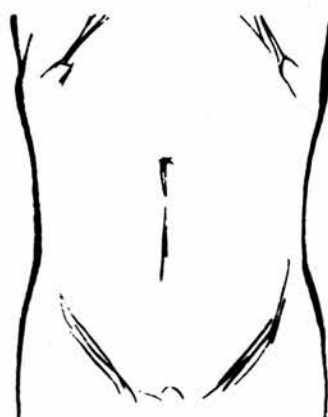
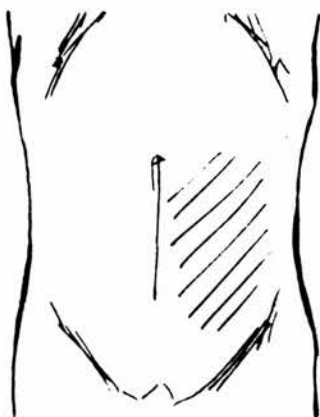
NAME M.M. AGE 80 DATE 17/5/72

DURATION OF SYMPTOMS Hours 3 Days
FIRST SYMPTOMS .. Pain. Vomiting. Diarrhoea. Nausea. Anorexia. Headache.
TYPE OF PAIN .. Colicky. Inflammatory. Constant. Varying. Intermittent.
SEVERITY OF PAIN .. 0. 1. 2. 3. 4.
LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L. Loins.
ONSET .. Hypochondrium. Back.
RADIATION OF PAIN .. R/L.I.F. Back. R/L. Loins. Shoulder Tip. Generalised.
VOMITING .. Absent. Before/After pain. Small. Medium. Profuse. Blood. Coffee Grounds. Bile.
NAUSEA .. Absent. Present.
ANOREXIA .. Absent. Complete. Partial.
BOWELS .. Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute..... days.
MICTURITION .. Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.
MENSTRUATION .. Normal. Recent irregularity.

TENDERNESS.

RIGIDITY.

TUMOUR.



Hyper
aesthesia

T. P. R.
FACIES .. Anxious. Nervous. Flushed. Grey. Nil of note.
ABDOMEN .. Fat. Medium. Thin. Distended. Visible peristalsis.
RECTAL EXAMINATION .. Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.
VAGINAL EXAMINATION .. Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.
CERVICAL GLANDS.. R/L. Large. Medium. Small. Tender/Not Tender.

PULSATILE

RECEIVING ROOM DIAGNOSIS DISSECTING AORTIC ANEURISM
OPERATION DIAGNOSIS (from Ward) FINAL DIAGNOSIS: LEAKING AORTIC ANEURISM

DIAGNOSTIC RADIOLOGY REPORT

PATIENT 2: M. M. 80 year old female

HISTORY:)
)
EXAMINATION:) see figure opposite

CASUALTY DIAGNOSIS: ? DISSECTING AORTIC ANEURYSM

RADIOLOGY REPORT: Chest x-ray: There is a shadow behind the heart which appears to be a large hiatus hernia.

Abdominal x-rays (erect and supine): There is marked calcification in the abdominal aorta which is shown to be aneurysmal.

FINAL CLINICAL DIAGNOSIS: DISSECTING ABDOMINAL AORTIC ANEURYSM.

ASSESSMENT OF RADIOLOGY REPORT: DIAGNOSTIC

PATIENT 3

UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

NAME M.W. AGE 4 yrs DATE 7/2/72

DURATION OF SYMPTOMS Hours 24 Days ..

FIRST SYMPTOMS Pain Vomiting. Diarrhoea. Nausea. Anorexia. Headache.

TYPE OF PAIN Colicky. Inflammatory. Constant. Varying. Intermittent.

SEVERITY OF PAIN 0. 1. 2. 3. 4.

LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L. Loin.

ONSET Hypochondrium. Back.

RADIATION OF PAIN R/L.I.F. Back. R/L. Loin. Shoulder Tip. Generalised.

VOMITING Absent. Before/After pain. Small. Medium. Profuse. Blood. Coffee Grounds. Bile. Faecal.

NAUSEA Absent. Present.

ANOREXIA Absent. Complete. Partial.

BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute.....days. Flatus.

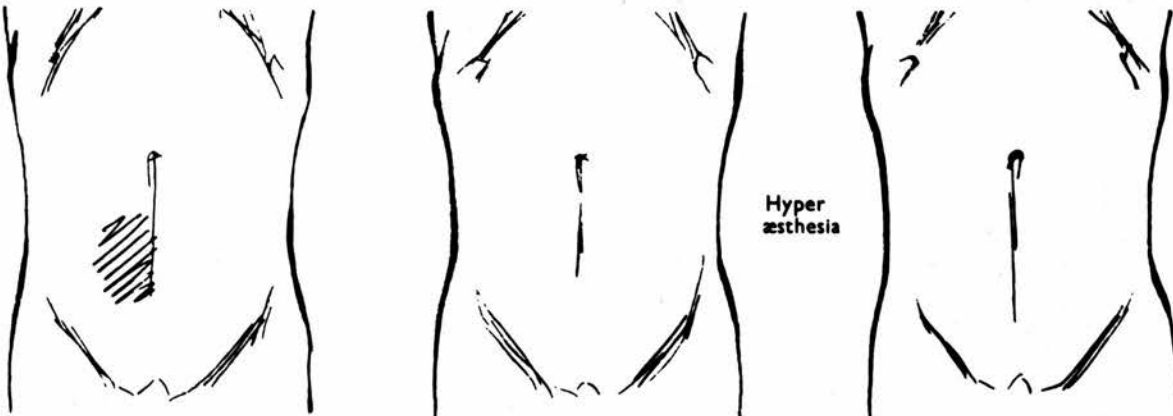
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.

MENSTRUATION Normal. Recent irregularity.

TENDERNESS.

RIGIDITY.

TUMOUR.



T. P. R.

FACIES Anxious. Nervous. Flushed. Grey. Nil of note.

ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.

RECTAL EXAMINATION .. Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.

VAGINAL EXAMINATION .. Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.

CERVICAL GLANDS.. .. R/L. Large. Medium. Small. Tender/Not Tender.

RECEIVING ROOM DIAGNOSIS .. ? ACUTE APPENDICITIS

OPERATION DIAGNOSIS (from Ward) .. FINAL DIAGNOSIS: ACUTE APPENDICITIS

R.R.4

RADIOLOGY REPORT OF HELP IN DIAGNOSIS

PATIENT 3: M. W. 9 years

HISTORY:)
EXAMINATION:) see figure opposite

CASUALTY DIAGNOSIS: ? ACUTE APPENDICITIS

RADIOLOGY REPORT: Chest x-ray: NAD

Abdominal x-rays (erect and supine): dilated small
bowel in central abdomen with only short fluid
levels not typical of obstruction. ? local ileus
due to inflammatory lesion.

FINAL CLINICAL DIAGNOSIS: ACUTE APPENDICITIS

ASSESSMENT OF RADIOLOGY REPORT: OF HELP IN DIAGNOSIS

PATIENT 4

UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

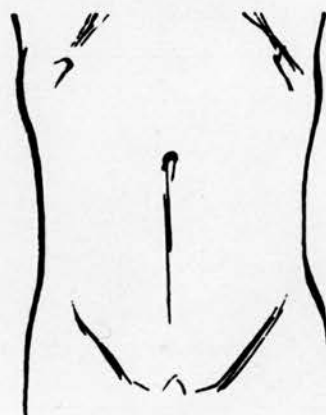
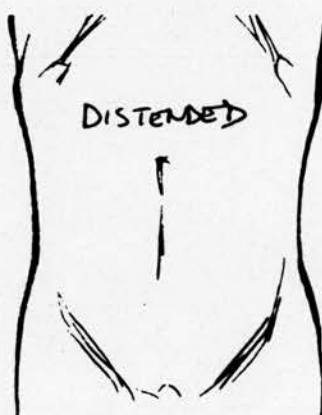
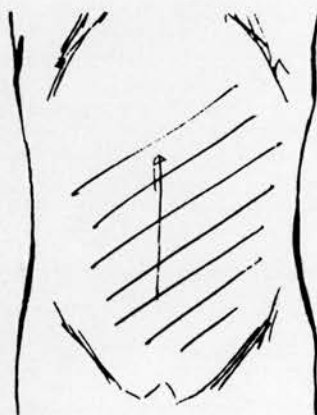
NAME J.S. AGE 72 DATE 16/2/72

DURATION OF SYMPTOMS Hours 24 Days ..
FIRST SYMPTOMS Pain. Vomiting. Diarrhoea. Nausea. Anorexia. Headache.
TYPE OF PAIN Colicky. Inflammatory. Constant. Varying. Intermittent.
SEVERITY OF PAIN 0. 1. 2. 3. 4.
LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L. Loin.
ONSET Hypochondrium. Back.
RADIATION OF PAIN .. R/L.I.F. Back. R/L. Loin. Shoulder Tip. Generalised.
VOMITING Absent. Before/After pain. Small. Medium. Profuse. Blood. Coffee Grounds. Bile.
Fæcal.
NAUSEA Absent. Present.
ANOREXIA Absent. Complete. Partial.
BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute..... days.
Flatus.
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.
MENSTRUATION Normal. Recent irregularity.

TENDERNESS.

RIGIDITY.

TUMOUR.



T. P. R.
FACIES Anxious. Nervous. Flushed. Grey. Nil of note.

ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.

RECTAL EXAMINATION .. Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.

VAGINAL EXAMINATION .. Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.

CERVICAL GLANDS.. R/L. Large. Medium. Small. Tender/Not Tender.

TINKLING
BOWEL SOUNDS

RECEIVING ROOM DIAGNOSIS INTESTINAL OBSTRUCTION

OPERATION DIAGNOSIS (from Ward) FINAL DIAGNOSIS: SMALL BOWEL OBSTRUCTION

R.R.4

RADIOLOGY REPORT OF HELP IN DIAGNOSISPATIENT 4: J. S. 72 years

HISTORY:)
EXAMINATION:) see figure opposite

CASUALTY DIAGNOSIS: ? OBSTRUCTIONRADIOLOGY REPORT: Chest x-ray: Azygos lobe. No heart or lung lesion seen.

Abdominal x-rays (erect and supine): several fluid levels
seen but no gross gaseous distention of bowel loops.
Appearances might suggest obstruction with fluid filled
bowel or an ileus.

FINAL CLINICAL DIAGNOSIS: SMALL BOWEL OBSTRUCTION DUE TO DIFFUSE
CARCINOMATOSIS

ASSESSMENT OF RADIOLOGY REPORT: OF HELP IN DIAGNOSIS

PATIENT 5

UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

NAME E.L. AGE 66 DATE 19/2/72

DURATION OF SYMPTOMS Hours 24 Days ..

FIRST SYMPTOMS Pain. Vomiting. Diarrhoea. Nausea. Anorexia. Headache.

TYPE OF PAIN Colicky. Inflammatory. Constant. Varying. Intermittent.

SEVERITY OF PAIN 0. 1. → 2. 3. 4.

LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L. Loin.

ONSET Hypochondrium. Back.

RADIATION OF PAIN .. R/L.I.F. Back. R/L. Loin. Shoulder Tip. Generalised.

VOMITING Absent Before/After pain. Small. Medium. Profuse. Blood. Coffee Grounds. Bile. Facal.

NAUSEA Absent. Present.

ANOREXIA Absent. Complete. Partial.

BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute..... days. Flatus.

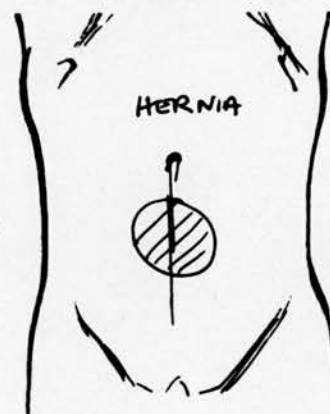
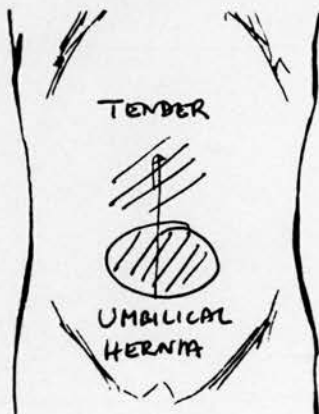
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.

MENSTRUATION Normal. Recent irregularity.

TENDERNESS.

RIGIDITY.

TUMOUR.



T. P. R.
FACIES Anxious. Nervous. Flushed. Grey. Nil of note.

ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.

RECTAL EXAMINATION .. Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.

VAGINAL EXAMINATION .. Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.

CERVICAL GLANDS.. .. R/L. Large. Medium. Small. Tender/Not Tender.

RECEIVING ROOM DIAGNOSIS OBSTRUCTED UMBILICAL HERNIA

OPERATION DIAGNOSIS (from Ward) FINAL DIAGNOSIS : IRREDUCIBLE UMBILICAL HERNIA

RADIOLOGY REPORT OF NO HELP IN DIAGNOSIS

PATIENT 5: E. L. 66 years

HISTORY:)
 }
EXAMINATION: } see figure opposite

CASUALTY DIAGNOSIS: ? OBSTRUCTION

RADIOLOGY REPORT: Chest x-ray: bilobed contour to right hemi-diaphragm.
No active lung lesion seen.

Abdominal x-rays (erect and supine): some faecal
loading but nil else significant.

FINAL CLINICAL DIAGNOSIS: OMENTUM (IRREDUCIBLE) IN UMBILICAL HERNIA

ASSESSMENT OF RADIOLOGY REPORT: OF NO HELP IN DIAGNOSIS

PATIENT 6

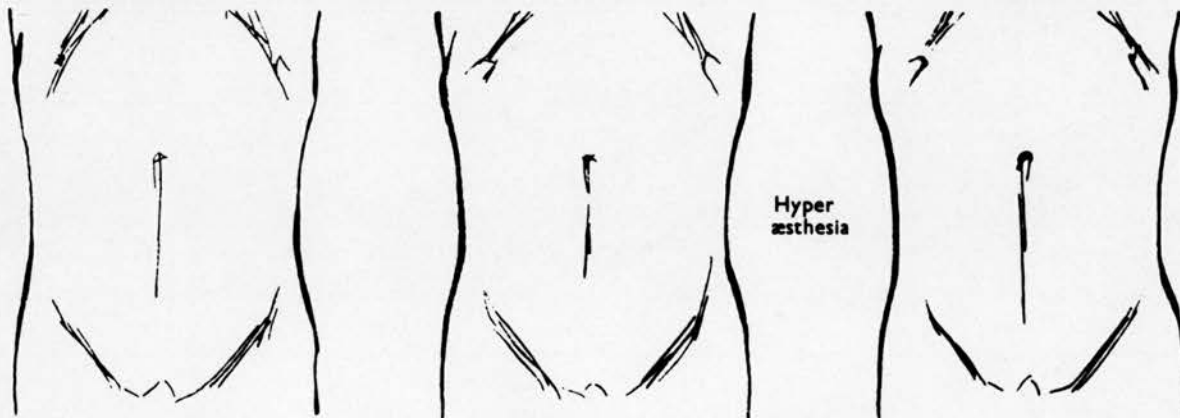
UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

NAME M. G. AGE 28 DATE 7/2/72
DURATION OF SYMPTOMS Hours 12 Days ..
FIRST SYMPTOMS Pain Vomiting. Diarrhoea. Nausea. Anorexia. Headache.
TYPE OF PAIN Colicky. Inflammatory. Constant. Varying. Intermittent.
SEVERITY OF PAIN 0. 1. 2. 3. 4.
LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L. Loin.
ONSET Hypochondrium. Back.
RADIATION OF PAIN R/L.I.F. Back. R/L. Loin. Shoulder Tip. Generalised.
VOMITING Absent. Before/After pain. Small. Medium. Profuse. Blood. Coffee Grounds. Bile.
NAUSEA Absent. Present.
ANOREXIA Absent. Complete. Partial.
BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute..... days.
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.
MENSTRUATION Normal. Recent irregularity. LMP 24/12/71 4/28

TENDERNESS.

RIGIDITY.

TUMOUR.



T. P. R.
FACIES Anxious. Nervous. Flushed. Grey. Nil of note.
ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.
RECTAL EXAMINATION Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE
VAGINAL EXAMINATION Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE
CERVICAL GLANDS.. .. R/L. Large. Medium. Small. Tender/Not Tender.

RECEIVING ROOM DIAGNOSIS ACUTE APPENDICITIS

OPERATION DIAGNOSIS (from Ward) FINAL DIAGNOSIS : ACUTE APPENDICITIS

R.R.4

RADIOLOGY REPORT OF NO HELP IN DIAGNOSIS

PATIENT 6: M. G. 28 years

HISTORY: }
EXAMINATION: } see figure opposite

CASUALTY DIAGNOSIS: APPENDICITIS

RADIOLOGY REPORT: Chest x-ray: No abnormality seen.

Abdominal x-rays (erect and supine): No abnormality seen.

FINAL CLINICAL DIAGNOSIS: ACUTE APPENDICITIS

PATIENT 7

UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

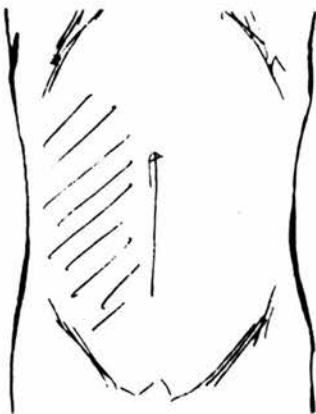
NAME M.O. AGE 45 DATE 15/4/72

DURATION OF SYMPTOMS Hours 36 Days ..
FIRST SYMPTOMS Pain Vomiting. Diarrhoea. Nausea. Anorexia. Headache.
TYPE OF PAIN Colicky. Inflammatory. Constant Varying. Intermittent.
SEVERITY OF PAIN 0. 1. 2. 3. 4.
LOCALISATION OF PAIN AT Generalised. Umbilical. R/L.I.F. Epigastric. Hypogastric. R/L Loin.
ONSET Hypochondrium. Back.
RADIATION OF PAIN R/L.I.F. Back. R/L Loin. Shoulder Tip. Generalised.
VOMITING Absent. Before After pain. Small. Medium. Profuse. Blood. Coffee Grounds. Bile. Faecal.
NAUSEA Absent. Present.
ANOREXIA Absent. Complete. Partial.
BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute days. Flatus.
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.
MENSTRUATION Normal. Recent irregularity.

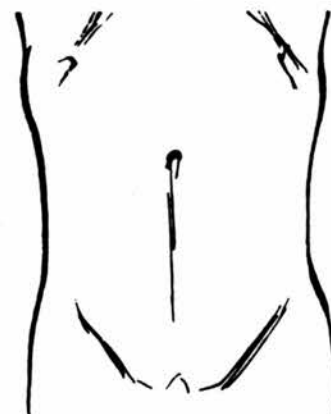
TENDERNESS.

RIGIDITY.

TUMOUR.



Hyper
æsthesia



T. P. R.
FACIES Anxious. Nervous. Flushed. Grey. Nil of note.
ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.
RECTAL EXAMINATION Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.
VAGINAL EXAMINATION Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.
CERVICAL GLANDS.. .. R/L. Large. Medium. Small. Tender/Not Tender.

RECEIVING ROOM DIAGNOSIS ? ACUTE APPENDICITIS

OPERATION DIAGNOSIS (from Ward) FINAL DIAGNOSIS ACUTE APPENDICITIS

R.R.4

RADIOLOGY REPORT CONSIDERED TO SUGGEST AN INCORRECT DIAGNOSIS

PATIENT 7: M. O. 45 years

HISTORY:)
)
EXAMINATION:) see figure opposite

CASUALTY DIAGNOSIS: ? APPENDICITIS

RADIOLOGY REPORT: Chest x-ray: No heart or lung lesion seen.

Abdominal x-rays (erect and supine): what is considered to be a prominent gall bladder shadow is seen causing some indentation of the transverse colon. No other abnormality seen.

FINAL CLINICAL DIAGNOSIS: ACUTE APPENDICITIS (no enlarged gall bladder at operation)

ASSESSMENT OF RADIOLOGY REPORT: MISLEADING

PATIENT 8

UNITED LEEDS HOSPITALS
THE GENERAL INFIRMARY AT LEEDS
CASUALTY DEPARTMENT AND RECEIVING ROOM

NAME R.K. AGE 40y DATE 12/3/72

DURATION OF SYMPTOMS Hours 24 Days ..

FIRST SYMPTOMS Pain. Vomiting. Diarrhoea. Nausea. Anorexia. Headache.

TYPE OF PAIN Colicky. Inflammatory. Constant. Varying. Intermittent.

SEVERITY OF PAIN 0. 1. (2) 3. 4.

LOCALISATION OF PAIN AT Generalised. Umbilical. R.L.I.F. Epigastric. Hypogastric. R/L Loin.

ONSET Hypochondrium. Back.

RADIATION OF PAIN R/L.I.F. Back. R.L. Loin. Shoulder Tip. Generalised.

VOMITING Absent. Before/After pain Small. Medium. Profuse. Blood. Coffee Grounds. Bile. Faecal.

NAUSEA Absent. Present

ANOREXIA Absent. Complete. Partial

BOWELS Diarrhoea. Blood. Mucus. Normal. Constipation. Absolute..... days.
Flatus.

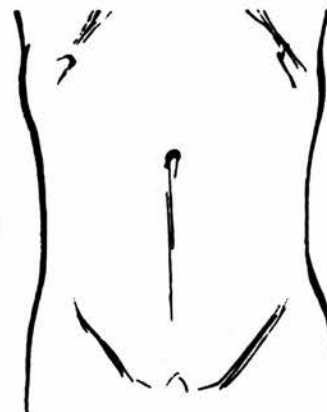
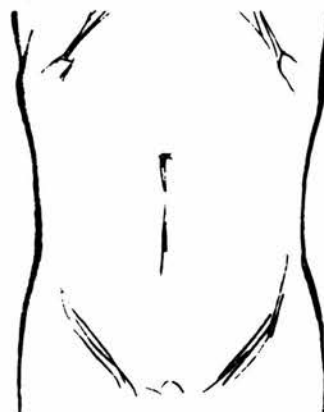
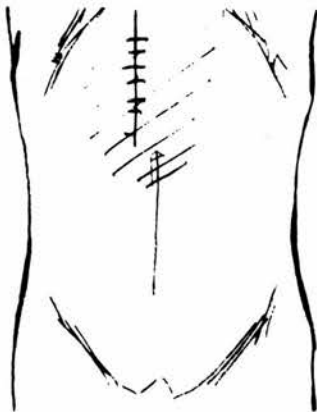
MICTURITION Normal. Frequency. Diurnal. Nocturnal. Strangury. Dysuria. Urgency. Haematuria.

MENSTRUATION Normal. Recent irregularity.

TENDERNESS.

RIGIDITY.

TUMOUR.



Hyper
aesthesia

Bowel sounds Present

T. P. R.

FACIES Anxious. Nervous. Flushed. Grey. Nil of note.

ABDOMEN Fat. Medium. Thin. Distended. Visible peristalsis.

RECTAL EXAMINATION Tenderness. Tumour. Blood. Mucus. N.A.D. NOT DONE.

VAGINAL EXAMINATION Tenderness. Tumour. Blood. Discharge. N.A.D. NOT DONE.

CERVICAL GLANDS R/L. Large. Medium. Small. Tender/Not Tender.

RECEIVING ROOM DIAGNOSIS INTESTINAL OBSTRUCTION

OPERATION DIAGNOSIS (from Ward) FINAL DIAGNOSIS: RECURRENT DUODENAL ULCER

R.R.4

RADIOLOGY REPORT CONSIDERED TO SUGGEST AN INCORRECT DIAGNOSIS

PATIENT 8: R. K. 40 years

HISTORY:)
EXAMINATION:) see figure opposite

CASUALTY DIAGNOSIS: INTESINAL OBSTRUCTION

RADIOLOGY REPORT: Chest x-ray: No evidence of disease.

Abdominal x-rays (erect and supine): there are at least two fluid levels in the right upper quadrant but with very little bowel distention. This could represent a localised closed loop obstruction but likely to be incomplete since air is seen throughout the colon. The upper of the fluid levels could be in the duodenal loop which if true, would imply slight obstruction.

FINAL CLINICAL DIAGNOSIS: RECURRENT DUODENAL ULCER (barium meal and endoscopy)

ASSESSMENT OF RADIOLOGY REPORT: MISLEADING

Discussion of Results

The purpose of this second part of the thesis is to determine whether or not the plain x-ray should be a routine investigation in the acute abdomen. The first group of patients which must be considered are those in which the x-rays contributed to the diagnosis (positive reports). In the author's series 42% of the x-rays were in this group comprising 'diagnostic' x-rays and x-rays which, although not diagnostic were contributory to the diagnosis.

Two examples of radiology reports which were considered 'diagnostic' have been quoted in full (patients 1 and 2), the diagnoses being an obstructing sigmoid carcinoma and a dissecting abdominal aortic aneurism. Other radiological features considered pathognomic were, for example, the dilated featureless bowel of toxic megacolon (fig. 45) and the dilated twisted loop of a sigmoid volvulus (fig. 42).

The group of radiological features considered to be 'contributory to diagnosis' without being diagnostic were those x-rays which showed a 'non-specific' radiological feature but which were nevertheless in keeping with the clinicians diagnosis. This group included such signs as localised right iliac fossa ileus in acute appendicitis (patient 3) or gastric and duodenal ileus in acute cholecystitis. In other cases the x-ray reports were suggestive of the diagnosis without being pathognomic (patient 4).

The second group of patients to be considered were those in which the x-rays were classified as non-contributory (patients 5 and 6) i.e. they showed neither pathognomic nor non-specific radiological signs. This group is the 'negative' group and contained 57% of the cases. It is important

to note that, for the purpose of this survey, only positive radiological signs were considered when making the classification of 'contributory to diagnosis'. In this series, because of the difficulty of 'retrospective assessment', the author did not consider the degree of 'negative help' of an x-ray. The fact that a certain x-ray sign is absent, or that an x-ray appears normal is often of equal importance to the clinician. Inclusion of this 'negative help' factor could only have raised the incidence of the 'contributory' group of x-ray reports.

To illustrate this point more clearly: the x-rays of cases of non-specific abdominal pain (NONSAP) which showed no specific radiological features were classified in my study as 'of no help'. It could be argued that, because no signs were shown, the accuracy of clinical diagnosis was improved and that, therefore, these NONSAP x-rays should be classified 'of help in diagnosis'. It should be noted that if the 35 cases of NONSAP in the series were classed as 'of help' instead of as 'of no help' the overall figures of the series would be radically altered.

NONSAP CASES CLASSED AS 'NO HELP' :

POSITIVE REPORTS: 42%

NEGATIVE REPORTS: 57%

NONSAP CASES CLASSIFIED AS 'OF HELP' :

POSITIVE REPORTS: 55%

NEGATIVE REPORTS: 44%

The third group considered were those in which the x-ray report was either 'wrong' or 'misleading'. This group is the 'false positive' group and was very small (1%). The two cases which were classified in this group

are discussed in full above. This classification was decided upon if the radiologist reported a radiological feature (either pathognomic or non-specific) which should not be present with that particular 'clinical diagnosis' (patients 7 and 8).

In summary, therefore, the criteria described above, produced the following data:

Contributory x-ray reports	42%
Non-contributory x-ray reports	57%
False positive x-ray reports	1%

Incorporating these results, the evidence for and against the routine use of the plain x-ray is discussed:-

Arguments against the routine x-ray

- (1) A non-contributory rate (negative yield rate) of 57% is too high to justify routine investigation

Some clinicians would say that a routine investigation which was non-contributory in 57 out of 100 patients was of little use when it is considered that the clinician's diagnostic accuracy on clinical examination alone is about 80% (Wilson, 1975).

- (2) It cannot be ethically justified to x-ray every acute abdominal patient for a positive yield rate of 42%

The dangers of excess irradiation make it unethical to recommend the use of routine radiological investigations.

- (3) The cost of the x-ray as a routine may not be justified in these days of economic recession - especially in the light of the Royal College of Radiologists' view that patients are being over investigated.

- (4) Acute abdominal x-ray examinations could never become routine because of the practical difficulty of providing the radiographic cover necessary for taking the x-rays

That is, radiographer cover would need to be available at short notice for the full 24 hour period, in addition to keeping the radiology department fully workable the whole time.

- (5) It is clinically unsound to x-ray every patient; only those in whom the diagnosis is in doubt should be x-rayed - this would make the positive yield rate much higher.
- (6) Accepting the yield figures quoted, in what percentage of cases do the x-rays actually make a difference to the patient's management? In other words, even though certain signs may be present on the x-rays, these do not alter the clinical management of the patient.

Evidence for making the plain x-ray routine

Six separate arguments against making the x-ray routine have been outlined above. The evidence in favour of the routine x-ray can be presented by answering each of these questions in turn:-

- (1) A positive yield rate of 42% for a 'single' investigation as found in this study, is very high. Consider the 'yield rates' of other investigations:-

(a) Clinical Investigations

In 1970, Prout published an article describing the significance of rebound tenderness in the acute abdomen in which the true positive rate of rebound was only 47% in a study of 100 abdomens. The false positive rate in the series was 14%.

(b) Radiological Investigation

Little data regarding the yield rates of radiological investigations is available in the literature. Recently Rees et al. (1976) found that routine pre-operative chest x-rays in non cardiopulmonary surgical patients showed significant changes in only 126 patients in a series of 667 (18%). At Otley General Hospital, Yorkshire, J. Swinburn (1976) reports a 63% positive yield rate in a series of 1,000 consecutive barium meals.

(c) Biochemical Investigation

Whitehead (1971) in a study of multiple biochemical analysis techniques reports that in a series of 7,236 biochemical tests requested, 82% were normal - giving a positive yield rate of only 18%.

- (2) From the ethical point of view, provided those patients in whom the possibility of pregnancy exists are excluded, the investigation can be justified because of the yield rate.
- (3) That the cost of the investigation as a routine procedure cannot be justified may be answered as follows:
 the cost of the plain x-ray series in terms of material is low (£1 per plate or £3 for the usual series of three). On an average emergency night at the Leeds Infirmary the radiographer on duty spends one quarter of her time performing emergency abdominal radiographs, at a cost to the National Health Service of £10 per night, when related to her overall salary. The "day-time" work

load of the Leeds Casualty is sufficient for the number of abdominal x-rays performed to be a very small percentage of the total work load. In terms of the current overall cost of the N.H.S. I do not think that the financial outlay for routine abdominal x-rays (as argued above) could be employed as an argument against their use.

- (4) The question of providing a 24 hour radiological service may also lead to difficulties from the staffing point of view. In the Leeds Infirmary the total number of radiographers employed is adequate to maintain a satisfactory acute duty rota, however, in the smaller district hospital this problem is much more difficult. It must be remembered, however, that the smaller the hospital the less the number of 'acute abdomens' admitted, and therefore, the less often the services of a radiographer will be required.

- (5) The argument that it would be more acceptable to x-ray only those patients in whom the diagnosis is still in doubt after clinical examination is, at first consideration, a reasonable one. The example usually quoted is 'if a child is admitted to hospital with central, colicky abdominal pain, radiating to the right iliac fossa with tenderness, and rebound tenderness, then the diagnosis of acute appendicitis is obvious and no x-rays are required'.

In practice, this premise of 'x-ray only the doubtful cases' is unacceptable on the following evidence:

For a period of 2 emergency days at the General Infirmary at Leeds it was decided to allow the casualty officer to decide which patients

should be x-rayed, by specifically asking him to x-ray only those cases in which he considered the diagnosis to be in doubt (this is in contradistinction to the usual policy of encouraging him to ask for x-rays in the majority of acute abdominal cases).

Of the 24 cases admitted on these 2 days 3 (13%) required further radiographs:-

- (1) A middle aged female involved in a road traffic accident who required a chest x-ray and further abdominal films. (patient was thought to have only minor injuries by the casualty officer - a more experienced registrar considered a chest radiograph and abdominal films to be necessary).
- (2) A young girl who complained of abdominal pain but who had no localising signs in her abdomen and who was subsequently shown to have gross pneumoperitoneum from a silent gastric perforation (no radiographs performed at admission).
- (3) A 35 year old male admitted with abdominal pain for observation and in whom the resident surgical officer required plain films to exclude the possibility of a ureteric calculus (no radiographs performed at admission).

From this short survey it was immediately apparent that the decision as to whether or not x-rays were required could not be delegated to the 'inexperienced' casualty officer.

Secondly, it was evident that the 'x-ray only if diagnosis is in doubt' was to the disadvantage of the patient and the surgical

staff in more ways than loss of an aid to diagnosis. Each patient who required further x-rays had to be transported back to the X-ray Department - this affected the patient as follows:

- (1) The patient had to wait for transport there and back (up to two hours), suffering the inconvenience of a further transfer from bed to trolley and a further wait in the Casualty X-ray Department.
- (2) The resident surgical officer could not assess the patient fully at his first visit but had to examine the patient, request further x-rays, await the patient's return and then reassess the patient with the x-rays.
- (3) The condition of the patient involved in the road traffic accident deteriorated before further x-rays were performed and the patient was taken to theatre without the necessary x-rays, a potentially dangerous situation.

The author concluded that it is the individual directly responsible for the patient's management who must decide whether the radiographs are required. A second study was therefore arranged to determine if the number of abdominal radiographs could be reduced when the author himself was resident surgical officer. The scheme outlined below was followed:

Scheme

- (1) A chest x-ray and erect and supine x-rays of all acute abdomen patients were taken in Casualty.
- (2) Each patient was examined by the author, who subsequently reviewed all the investigations, except the x-rays.
- (3) The author then decided whether or not he required an x-ray, thus determining whether Channel A or Channel B (see over) was followed:-

Channel A

x-ray not required.

(a) Was the author's diagnosis correct?

(b) If diagnosis was incorrect, would x-rays have helped?

Channel B

x-ray required.

(a) Did the x-rays help in the positive sense?

(b) Did the x-rays help in the negative sense?

(x-rays were available for review at this stage because, in fact, all patients were still being x-rayed)

At present, 30 patients have been assessed in this way but the trial continues. No definite conclusions can, as yet, be drawn but two important points have emerged.

- (1) The percentage of patients selected for Channel A is very small (less than 10 per cent) and consists almost entirely of young children who require a laparotomy to exclude appendicitis.
- (2) In those cases selected into Channel B, 45 per cent have shown positive signs, but in every case where no specific radiological signs have been identified the author has assessed the x-rays as being of 'negative value'.

Some clinicians would argue that the plain abdominal x-rays should not be made routine because it is rare for the x-rays themselves to influence the clinical management of the patient. However, the x-ray must not be considered as an absolute diagnostic technique, but rather as one of a series of investigations. To condemn the x-ray because of its lack of absolute specificity is the same as saying 'how often does the rectal

examination decide whether or not a patient will be operated on for suspected appendicitis'. The answer is 'very rarely' but it is not suggested that a rectal examination should not be performed for that reason. The x-ray examination remains another piece of information, which when added to the history, clinical examination and other investigations, is used in the overall assessment of the patient.

The author's opinion, based on the evidence presented above, is that the plain abdominal x-ray should become a routine investigation in the acute abdomen. Inevitably the evidence is prejudiced by a personal opinion, but it is possible to subject the evidence to independent opinion in the following way:-

If the plain abdominal x-rays were to be made routine they would constitute a form of 'patient screening' because their inclusion as an investigation is no longer designated by any specific indications. The words 'screening procedure' are placed in parenthesis because, in the terms of public health medicine, a screening procedure is defined as a medical investigation which does not arise from a patient's request for advice for specific complaints. In this case the screening procedure is applied to a group of people with a specific complaint (the acute abdomen). Its 'usefulness' can, however, be assessed by subjecting the investigation to the same evaluation used to assess any screening programme before it becomes accepted for use.

In 1968 the Nuffield Hospital Trust financed a Working Group to investigate the problem of screening in medical care. One of the achievements of this Working Group, was to produce a standard procedure for the validation of screening procedures; each suggested programme is subjected to the following format, the relevant answers in the context of the acute abdominal

x-rays being provided:-

(A) Definition of the problem

1. What abnormality of medical significance is to be predicted or detected?

The abnormalities in the plain abdominal x-rays in the acute abdomen have been fully discussed and evaluated in the first part of this thesis.

2. What prevention or therapy is to be offered?

The treatment of the acute abdomen is well defined. An accepted line of management exists for all diseases involved in this investigation.

3. Which group(s) is to be screened?

All patients requiring admission to hospital with diagnosis of acute abdomen.

4. At what stage(s) is detection aimed?

In this case, the investigation is instigated by the patient's complaints, i.e. he is already showing evidence of a disease process.

(B) Review of the position before screening

1. Evidence concerning the prevalence, natural history and medical significance of the abnormality, with conclusions on the adequacy of the evidence

The five acute abdominal diseases studied in the first part of this thesis (acute appendicitis, acute cholecystitis, acute pancreatitis, perforated duodenal ulcer and intestinal obstruction) accounted for 4,000 deaths in the years 1973/74. (Registrar General's Statistical Review, 1974). Approximately 50 percent of the general surgical admissions to the Leeds Infirmary during that same period were surgical emergencies (Wilson,

1976). If we assume this figure to be representative of the rest of England, then at any one time 15,000 beds are occupied by surgical emergencies (there are 30,000 general surgical beds in this country). Thus 4% of the total number of hospital beds available at any one time in this country are occupied by surgical emergencies (Social Services Statistics, 1974).

Clinical experience shows that the earlier the diagnosis is made the less mortality - this is emphasised by the mortality figures for acute appendicitis.

If appendicectomy is performed before perforation has occurred, the mortality is 0.2 - 0.4 per cent. If the appendix has perforated and there is infective peritonitis, the mortality rises to 3 - 5 per cent, (Shepherd, 1968d).

Morbidity figures are more difficult to compile, but all surgeons are aware of the added morbidity caused by delay in diagnosis.

2. Evidence concerning effectiveness of previous methods of treating the disease

Again this can be exemplified by reviewing the figures for acute appendicitis quoted in Part I of this thesis. In 1960, 500 people died from acute appendicitis, and although the figure had fallen to 259 in 1970 (Registrar General's Statistical Review, 1972) this is still an unacceptable level of mortality.

(C) Review of evidence concerning the 'screening procedure'

1. Evidence concerning the effectiveness of the proposed diagnostic methods

(a) Applicability to group where investigation is proposed

Part I of the thesis considered in detail the occurrence of specific

changes in the acute abdominal x-ray and indicates its applicability to this disease state.

(b) Error rates, positive and negative

Part II of the thesis showed an overall positive yield rate of 42 per cent and negative rate of 57 per cent. The false positive rate was only 1 per cent.

(c) Comparison with traditional diagnostic methods

Figures available on the use of clinical diagnosis of the acute abdomen (without investigation) give a diagnostic accuracy of 73 - 84 per cent (Wilson et al., 1975). The use of investigations to improve this accuracy if possible to 100 per cent must be considered.

(d) Availability of resources

In large teaching hospitals and most district general hospitals, the resources for the investigations are immediately available. Only in the smaller hospitals would the problem of night radiology cover arise.

(e) Cost

Details of the cost, as discussed earlier have shown that the relative cost of the x-rays, when compared to the overall cost of the radiology department, is small.

2. Evidence concerning the effectiveness of the proposed treatment

The treatment of the acute abdomen is more effective the earlier the diagnosis is made. This is well illustrated by the early diagnosis and treatment of acute appendicitis (before generalised peritonitis occurs) with bowel obstruction (before perforation or gangrene occurs) with viscus

perforation (the less the period of generalised peritonitis, the less the morbidity and mortality).

(D) Conclusions concerning the state of evidence on the problem as a whole

The acute abdomen is one of the major causes of hospital admissions in this country as is shown from the figures in paragraph (B), Part 1. The effectiveness of treatment is directly related to the stage of the disease at which it is diagnosed (i.e. the earlier the diagnosis, the better the prognosis). With a clinician diagnosis rate of 70 - 80 per cent, a single investigation with a positive yield rate of approximately 40 per cent is desirable. The facilities necessary for this investigation are immediately available in the majority of hospitals and no additional cost other than radiography cover (in some cases) would be necessary.

(E) Proposals for acquisition of further evidence

1. The degree of negative help which the abdominal x-ray gives is obviously important and additional favourable evidence for x-ray as a routine procedure will come from consideration of this factor. The results of the study outlined in section 5 (evidence in favour of routine x-rays, page 110) will provide further evidence.
2. The difference which the plain x-ray makes to the overall diagnostic rate will be calculated from the results of this same study. The figures for clinicians' diagnostic accuracy are those calculated by Mr. F. T. de Dombal (1976) in the University Department of Surgery at Leeds. The clinicians' diagnosis has been improved by 'computer aided diagnosis' and it is hoped that by programming the computer with the results from

Part 1 of the thesis and carrying out a routine abdominal x-ray on all cases submitted to computer aided diagnosis, that a further increase in the diagnostic rate can be shown statistically.

(F) Proposals for initial application

It is suggested by the author that the routine x-ray examination of the acute abdomen is indicated. All cases of the 'acute abdomen' necessitating hospital admission should receive a chest x-ray and an erect and supine abdominal x-ray, excepting those who are too ill for the procedure, or in whom the chance of pregnancy exists.

SUMMARY

1. A consecutive series of 249 acute abdominal admissions were submitted to routine plain abdominal and chest films.
2. Radiography showed positive signs in 42 per cent of cases. 57 per cent of cases were classified as non-helpful. The false positive rate was 1 per cent.
3. The 'negative value' of the x-rays was not considered in this study.
4. Evidence for and against the use of the plain abdominal x-ray as a routine investigation is presented.
5. The author's opinion, based on the evidence presented and by subjecting the investigation to a 'screening in medical care' evaluation is that the plain abdominal radiography should be a routine investigation in all cases of the acute abdomen.

PART III

WHO SHOULD REPORT THE ACUTE ABDOMINAL X-RAY?

INTRODUCTION

In this country, especially in the major teaching hospital centres, it is the junior surgical staff who are largely responsible for the diagnosis and management of the surgical emergencies. When acute abdominal x-rays are requested, they are usually assessed by the surgical staff themselves and it is unusual for an immediate radiological report to be available. The final part of this thesis is designed to ascertain whether or not the 'surgical' interpretation of the plain x-ray is sufficiently accurate, or whether a service of emergency radiology reporting should be made available.

MATERIALS AND METHOD

A questionnaire was prepared (see appendix I) in which the participant was asked to report 50 plain abdominal x-rays. A short case history was provided with each x-ray and the participant was asked to list the radiological features seen and, in the majority of cases to suggest a diagnosis. The x-rays were chosen so that all but two included one or more specific radiological features; the participants were informed in the instructions that the questionnaire contained normal x-rays.

Figures 69-71, 81, 86, and 91-93 are illustrations of the type of x-ray included in the questionnaire, the accompanying case history and question being shown opposite.

The questionnaire was submitted to radiologists and surgeons of varying clinical experience from the grade of Casualty Officer to Consultant. Five radiologists and 5 surgeons were included in each grade and the average

score of each group was calculated as a percentage of the maximum score possible.

In order that the clinical situation should be as closely adhered to as possible, no time limit was placed on the time taken to assess each of the x-rays and several of the participants completed the questionnaire at 'more than one sitting' rather than in one single attempt.

The assessment of each questionnaire after completion was performed by the author using a standard answer sheet.

RESULTS

The average score of each group of participants is shown in Table 26 and was calculated as a percentage of the maximum score of 100%. The individual scores for each group lay within very narrow limits (see Table 27). The highest score of the questionnaire was obtained by the consultant radiologists (95%) compared to a score of 70% by the consultant surgeons. The score of the senior registrar radiologists was 88% and that of the senior registrar surgeons 81%. The radiology registrars scored 60% and the surgical registrars 61%. The lowest score of the questionnaire was that of the casualty officer group, being 57%.

DISCUSSION

It came as no surprise that the score of the consultant radiologists was higher than that achieved by others. The scores of the senior registrar radiologists, senior registrar surgeons and consultant surgeons reflected a high 'success' rate in diagnosis, and few serious mis-

TABLE 26

AVERAGE SCORE OF RADIOLOGISTS AND SURGEONS
IN ACUTE ABDOMINAL X-RAY QUESTIONNAIRE

Average percentage score of
5 participants
(maximum score = 100%)

Grade	Radiologist	Surgeon
Consultant	95	70
Senior Registrar	88	81
Registrar	60	61
Casualty Officer	-	57

TABLE 27

INDIVIDUAL SCORES OF SURGEONS AND RADIOLOGISTS

IN PLAIN X-RAY QUESTIONNAIRE

(Maximum Score 65 points)

	RADIOLOGIST					SURGEON				
	1	2	3	4	5	1	2	3	4	5
CONSULTANT	60	62	60	59	63	46	47	40	50	48
SENIOR REGISTRAR	57	55	59	60	56	53	55	51	50	52
REGISTRAR	39	35	40	43	38	47	39	34	40	41
CASUALTY OFFICER	-	-	-	-	-	37	33	39	38	37

diagnoses were made in this group.

The major differences in score, and type of answer submitted, came at the level between the senior registrar and registrar group, both for surgeons and radiologists. The standard of x-ray assessment of the registrar and casualty officer group was, in the author's opinion, unacceptable. Not only were the finer details of the acute abdominal x-rays missed, but much more serious, mis-diagnoses were made, and in many cases 'standard' x-ray appearances were either missed completely or misinterpreted. For example, distinctions between small and large bowel obstruction were often confused. The limitations of x-ray interpretation at this level of clinical experience becomes much more serious when it is remembered that it is the surgical registrar who assesses the acute admission, interprets the x-rays and performs the treatment, often without recourse to an opinion from a more senior colleague.

Some improvement in the score of the surgeons of all grades could undoubtedly be produced by more formal instruction by consultant radiologists. However, in this time of medical specialisation, it is the author's opinion that immediate radiological reporting of the plain x-rays should be made routinely available. The results of the questionnaire have shown that this would benefit both the patient and the surgeon. Many would say that this suggestion is impossible from the medical 'manpower' point of view. In a teaching hospital, however, there are often more senior registrar radiologists than surgical senior registrars and registrars and it would certainly be possible, for example at the Leeds General Infirmary, for the senior registrar radiologists to work on an acceptable rota so that their opinion would be available at all times of the day and night on emergency days. In the

peripheral hospitals where no senior registrars are available, the problem of the night cover would be more difficult. However, in the smaller hospitals, the surgical acute load admitted at night is much smaller and it would certainly be possible for immediate acute reporting to be available during the routine working hours.

It is perhaps worth commenting that in the United States, where payment is largely on a 'fee for service' basis, that it is not the practice for a surgeon to interpret his own plain x-rays.

Looking more to the future, the reporting of plain x-rays is one service which would lend itself to centralisation. As closed circuit television facilities of up to 2,000 lines becomes available (as compared to the standard 625 lines in use commercially at present) the definition produced will be sufficient for x-rays to be televised to a central reporting zone, especially with the use of a zoom lens to allow details of selected zones to be visualised on the television monitor.

SUMMARY AND CONCLUSION

The average scores of surgeons and radiologists in a questionnaire containing 50 plain abdominal x-rays are presented. It is suggested from the results that if maximum benefit is to be obtained, the plain abdominal x-rays must be reported, at the time of the investigation, by a senior radiologist.

CONCLUSION

CONCLUSION

Because in the current situation in this country, the management of the acute abdominal emergency (including the assessment of the plain x-rays) is largely carried out by the resident surgical officer it was felt important to assess the acute abdominal x-rays from the junior surgeon's point of view, rather than the point of view of the radiologist with his more specialised knowledge. At the outset three basic questions were considered, and the answers to these questions sought in the subject material of the thesis. The following conclusions were drawn:

Question: Which radiological signs are present in the plain x-ray in the acute abdomen and with what incidence?

Answer: Table 28 shows the incidence in this series of those specific x-ray features which are reported in the literature as occurring in the plain x-ray in the five acute abdominal diseases studied. One or more of the features occurred in the x-rays of not less than 48% of the patients studied, the lowest incidence being in acute appendicitis and the highest in large bowel obstruction. It must be emphasized, however, that although the figures quoted in table 28 give the absolute incidence of the various signs, from the practical point of view the value of the signs was much less certain. In the discussion and summary of each section of the first part of the thesis the author has attempted to critically analyse the results for those signs

Table 28

THE INCIDENCE OF PLAIN X-RAY FEATURES
IN FIVE ACUTE ABDOMINAL CONDITIONS

DISEASE	% Showing x-ray sign(s)
ACUTE APPENDICITIS	48
ACUTE CHOLECYSTITIS	64
ACUTE PANCREATITIS	60
PERFORATED DUODENAL ULCER	60
SMALL BOWEL OBSTRUCTION LARGE BOWEL	97 100

which he considered to be of practical use to the surgeon in his management of the patient.

Question: Should plain x-rays be routinely performed in the acute abdomen?

Answer: In the 249 patients studied in the second part of the thesis it was found that the x-rays of 42% were of 'positive' value in diagnosis. It is emphasised in the discussion that consideration of the 'negative' value of the x-rays would only serve to increase the importance of the plain x-ray. Based on the results of this series the author concludes that given available finance and facilities the plain x-ray should become a routine in the assessment of every acute abdominal case. It is emphasised that the plain x-ray should be considered as one more 'investigatory tool' in the overall assessment of the patient rather than an investigation on which one would ultimately decide whether or not the patient requires operative treatment.

Question: Who should report the acute abdominal x-ray?

Answer: Comparison of the scores of surgeons and radiologists in assessing the plain x-ray, indicated that maximum benefit to both the surgeon and the patient would be obtained only if a senior radiological opinion were available at the time the investigation was performed. It is suggested that, at least in the bigger teaching and district hospitals, a suitable 'rota' could be arranged to provide this facility.

It is, perhaps, both salutary and appropriate to conclude this thesis by acknowledging that, in spite of devoting five years to studying in detail the plain x-ray in the acute abdomen, and thereby acquiring some specialist knowledge of the subject, the author would still choose, as a surgeon, to have the x-rays of his own acute abdominal patients assessed by a senior radiologist prior to any operative intervention.

'To know that you know what you know, to know that you do
not know that which you do not know, that is to know! '

BIBLIOGRAPHY

- Andersen, K. and Ringsted, A. (1943) Clinical and experimental investigations on ileus with particular reference to genesis of intestinal gas, Acta Chir Scand, 88, 475 - 502.
- Andersson, A. and Zenderfeldt, B. (1969) Gallstone ileus, Acta Chir Scand, 135, 713 - 717.
- Armitage, H. V. (1970) Pneumoperitoneum associated with jejunal diverticulosis, Pa Med, 73, 61 - 62.
- Bailey, H. and Love, R. J. M. Short Practice of Surgery, 11th ed. London: Lewis, 1959, 571.
- Bailey, H. and Love, R. J. M. Short Practice of Surgery, 15th ed. rev. by Rains, A. J. H. and Capper, W. M. London: Lewis, 1971, 769.
- Baylin, G. J. and Weeks, K. D. (1944) Some roentgen aspects of pancreatic necrosis, Radiology, 42, 466 - 470.
- Berk, J. E. (1946) Pneumoperitoneum following gastroscopy without evidence of perforation at laparotomy 14 hours later, Gastroenterology, 6, 218.
- Berg, R. M. and Berg, H. M. (1957) Coproliths, Radiology, 68, 839 - 844.
- Bilger, M. (1956) Pneumatosis cystoides intestinalis in children, report of a case complicated with fatal pneumoperitoneum, J. Paediat., 49, 445 - 449.
- Bird, G.C., Jr., Fissel, G. E. and Young, B. R. (1948) A pathognomonic roentgen sign of retroperitoneal abscess; report of 2 cases of ruptured appendix with positive roentgen findings, Am J Roentgenol Radium Ther, 59, 351 - 353.
- Bohrer, S. P. (1966) Typhoid perforation of the ileum, Br J Radiol, 39, 37 - 41.
- Botsford, T.W., Healey, S. J. and Veith, F. (1967) Volvulus of the colon, Am J Surg, 114, 900 - 903.
- Brady, B. M. and Carroll, D. S. (1957) The significance of the calcified appendiceal enterolith, Radiology, 68, 648 - 653.
- Brascho, D. J., Reynolds, T. N. and Zanca, P. (1962) The radiographic "colon cut-off sign" in acute pancreatitis, Radiology, 79, 763 - 769.
- Brockis, J. G. and Gilbert, M. C. (1957) Intestinal obstruction by gallstones: a review of 179 cases, Br J Surg, 44, 461 - 466.

- Brooks, D. W. Jr. and Killen, D. A. (1965) Roentgenographic findings in acute appendicitis, Surgery, 57, 377 - 384.
- Byrne, J. J. (1968) Treating large-bowel obstruction, Postgrad Med, 44, 237 - 243.
- Cantor, M. O. and Reynolds, R. P. Gastro-intestinal obstruction. Baltimore: Williams and Wilkins, 1957.
- Caruso, R. D. and Berk, R. N. (1971) The fuzzy fluid level sign, Radiology, 98, 369 - 372.
- Castronovo, E. (1929) Radiological failures of subacute and chronic intussusception, Radiol Med, 16, 917 - 954.
- Caves, P. K. and Crockard, H. A. (1970) Pseudo-obstruction of the large bowel, Br Med J, 2, 583 - 586.
- Chesterman, J. T. (1944) Two effects of retrograde nervous thrombosis in intestinal strangulation, J Path Bact, 56, 442 - 443.
- Dawson, J. L., Hanon, I. and Roxburgh, R. A. (1965) Diverticulitis coli complicated by diffuse peritonitis, Br J Surg, 52, 354 - 357.
- DeBakey, M. (1940) Acute perforated gastroduodenal ulceration; a statistical analysis and review of the literature, Surgery, 8, 852 - 884; 1028 - 1076.
- De Dombal, F. T. (1976) Personal communication.
- Dudley, H. A. F., Sinclair, I. S. R., McLaren, I. F., McNair, T. J. and Newsam, J. E. (1958) Intestinal pseudo-obstruction, J R Coll Surg Edinb, 3, 206 - 217.
- Donaldson, S. A. (1958) The management of perforated carcinoma of colon, New Engl J Med, 258, 201-207.
- Edmondson, H. A., Berne, C. J., Homann, R. E., Jr. and Wertman, M. (1952) Calcium, potassium, magnesium and amylase disturbances in acute pancreatitis, Am J Med, 12, 34 - 42.
- Elliott, G. and Elliott, K. (1963) The roentgenologic pathology of so-called pneumatosis cystoides intestinalis, Am J Roentgen R, 89, 720.
- Enge, I. and Frimann-Dahl, J. (1964) Radiology in acute abdominal disorders due to Meckel's diverticulum, Br J Radiol, 37, 775 - 780.
- Esquerro-Gomez, G. and Arango, O. (1963) Emphysematous cholecystitis. Report of seven cases, Radiology, 80, 369 - 373.

- Essenhigh, D. M. (1966) Management of acute cholecystitis, Br J Surg, 53, 1032 - 1038.
- Felson, B. and Bernhard, C. M. (1947) The roentgenologic diagnosis of appendiceal calculi, Radiology, 49, 178 - 191.
- Felson, B. and Wiot, J. F. (1973) Another look at pneumoperitoneum, Semin Roentgenol, 8, 437 - 443.
- Fishbein, R., Murphy, G. P. and Wilder, R. J. (1962) The pleuropulmonary manifestations of pancreatitis, Dis Chest, 41, 392 - 397.
- Fitzgerald, J. B., Crawford, E. S. and DeBakey, M. E. (1960) Surgical considerations of non-penetrating abdominal injuries: an analysis of 200 cases, Am J Surg, 100, 22 - 29.
- Frimann-Dahl, J. (1944) On strangulating obstruction of the small bowel with special reference to cases with poor roentgen findings, Acta Radiol (Stockh), 25, 480 - 492.
- Frimann-Dahl, J. (1948) Direct demonstration of perforated ulcers, Acta Radiol (Stockh), 30, 177 - 181.
- Frimann-Dahl, J. (1951) Radiological experiences in true strangulating obstructions, Acta Radiol (Stockh), 35, 85 - 100.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 2nd ed. Springfield (Ill.): Charles C. Thomas, 1960, 34 - 333.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1974(a), 368 - 385.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1974(b), 394.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1974(c), 400 - 413.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1974(d), 414 - 430.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1974(e), 46 - 59.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1974(f), 103 - 165.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1974(g), 166 - 176.

- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed.
Springfield (Ill.): Charles C. Thomas, 1974(h), 185 - 198.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed.
Springfield (Ill.): Charles C. Thomas, 1974(i), 279 - 313.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed.
Springfield (Ill.): Charles C. Thomas, 1974(j), 233 - 259.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed.
Springfield (Ill.): Charles C. Thomas, 1974(k), 324 - 332.
- Frimann-Dahl, J. Roentgen examinations in acute abdominal diseases, 3rd ed.
Springfield (Ill.): Charles C. Thomas, 1974(l), 59 - 77.
- Gammill, S. L. and Nice, C. M., Jr. (1972) Air fluid levels - their occurrence
in normal patients and their role in the analysis of ileus, Surgery, 71,
- Goligher, J. C. Surgery of the anus, rectum and colon, 3rd ed.
London: Bailliere Tindall, 1975, 481 - 518.
- Goligher, J. C., Hoffman, D. C. and de Dombal, F. T. (1970) Surgical
treatment of severe attacks of ulcerative colitis with special
reference to the advantages of early operation, Br Med J, 4, 703 - 706.
- Goligher, J. C. and Smiddy, F. G. (1957) The treatment of acute obstruction
or perforation with carcinoma of the colon and rectum, Br J Surg, 45,
270 - 274.
- Glenn, F. and McSherry, C. K. (1971) Obstruction and perforation in colo-
rectal cancer, Ann Surg, 173, 983 - 992.
- Glenn, F. and Thorbjarnarson, B. (1963) The surgical treatment of acute
cholecystitis, Surg Gynec Obstet, 116, 61 - 70.
- Graham, A. D. and Johnson, H. F. (1966) The incidence of radiographic findings
in acute appendicitis compared to 200 normal abdomens, Milit Med, 131,
272 - 276.
- Grollman, A. I., Goodman, S. and Fine, A. (1950) Localized paralytic ileus;
an early roentgen sign in acute pancreatitis, Surg Gynecol Obstet, 91,
65 - 70.
- Hall-Craggs, E. C. B. (1960) Sigmoid volvulus in an African population,
Br Med J, 1, 1015 - 1017.
- Hunt, C. J. (1948) Early diagnosis and roentgen manifestations of obstruction
of small bowel, Arch Surg, 57, 460 - 469.

- Immelman, E., Krige, H. and Bank, S. (1963) Radiological changes in bone due to intramedullary fat necrosis in pancreatitis. A preliminary report, Clin Radiol, 14, 273 - 275.
- Jones, Peter F. Emergency abdominal surgery in infancy, childhood and adult life. Oxford: Blackwell Scientific, 1974(a), 575.
- Jones, Peter F. Emergency abdominal surgery in infancy, childhood and adult life. Oxford: Blackwell Scientific, 1974(b), 423 - 467.
- Jones, Peter F. Emergency abdominal surgery in infancy, childhood and adult life. Oxford: Blackwell Scientific, 1974(c), 305 - 307.
- Jones, Peter F. Emergency abdominal surgery in infancy, childhood and adult life. Oxford: Blackwell Scientific, 1974(d), 382 - 387.
- Jones, Peter F. Emergency abdominal surgery in infancy, childhood and adult life. Oxford: Blackwell Scientific, 1974(e), 374 - 378.
- Lazarus, S. (1964) Perforated peptic ulcer in Israel, Gut, 5, 590 - 596.
- Levene, G., and Kaufmann, S. A. (1957) Roentgenologic findings in acute diseases in the abdomen. Med. Clin. North Am., 41, 1303-1326.
- Levin, B. (1973) Mechanical small bowel obstruction, Semin Roentgenol, 8, 281 - 297.
- Lockwood, I. H., Smith, A. B. and Walker, J. W. (1948) Acute small intestinal obstruction, Radiology, 51, 310 - 318.
- Love, L. (1973) Large bowel obstruction, Semin Roentgenol, 8, 299 - 322.
- McCort, J. J. (1960) Extra-alimentary gas in perforated appendicitis. Report of six cases, Am J Roentgenol Radium Ther Nucl Med, 84, 1087 - 1092.
- McCort, J. J. (1973) Acute hepatobiliary disease, Semin Roentgenol, 8, 389 - 403.
- MacKay, C. (1966) Perforated peptic ulcer in the West of Scotland: a survey of 5,343 cases during 1954-63, Br Med J, 1, 701 - 705.
- Mavor, G. E., Lyall, A. D., Chrystal, K. M. R. and Tsapogas, M. (1962) Mesenteric infarction as a vascular emergency. The clinical problems, Br J Surg, 50, 219 - 225.
- Mellins, H. Z. and Rigler, L. G. (1954) The roentgen findings in strangulating obstructions of the small intestine, Am J Roentgenol Radium Ther Nucl Med, 71, 404 - 415.
- Miller, R. E. (1960) Perforated viscus in infants: a new roentgen sign, Radiology, 74, 65 - 67.

- Miller, R. E. and Nelson, S. W. (1971) The roentgenologic demonstration of tiny amounts of free intraperitoneal gas: experimental and clinical studies, Am J Roentgenol Radium Ther Nucl Med, 112, 574 - 585.
- Moloney, G. E., Russell, W. T. and Wilson, D. C. (1950) Appendicitis - a report on its social pathology and recent surgical experience, Br J Surg, 38, 52 - 64.
- Morton, J. H., Schwartz, S. I. and Gramiak, R. (1960) Ileus of the colon, Arch Surg, 81, 425 - 434.
- Musgrove, J. E. (1952) Unusual roentgenographic findings in gangrenous appendicitis, Can Med Assoc J, 67, 666 - 667.
- Norpoth, H. (1950) Beitrage zur Frage des spontanen Pneumoperitoneums, Zentralbl Chir, 75, 450 - 455.
- Nuffield Provincial Hospitals Trust, Screening in Medical Care.
London: Oxford University Press, 1968, 1 - 13.
- Ottinger, L. W. and Austen, W. G. (1967) A study of 136 patients with mesenteric infarction, Surg Gynecol Obstet, 124, 251 - 261.
- Pollock, A. V. (1959) Acute pancreatitis; an analysis of 100 patients, Br Med J, 1, 6 - 14.
- Poppel, M. H. (1968) The roentgen manifestations of pancreatitis, Semin Roentgenol, 3, 227 - 241.
- Price, C. W. R. (1956) The "colon cut-off" sign in acute pancreatitis, Med J Aust, 1, 313 - 314.
- Prout, W. G., (1970) The significance of rebound tenderness in the acute abdomen, Br J Surg, 57, 508 - 512.
- Rees, A. M., Roberts, C. J., Bligh, A. S. and Evans, K. T. (1976)
Routine pre-operative chest radiography in non-cardiopulmonary surgery, Br Med J, 1, 1333 - 1335.
- Registrar General's Statistical review of England and Wales for the year 1968.
Part I Tables, medical. London: H.M.S.O., 1970.
- Registrar General's Statistical review of England and Wales for the year 1969.
Part I Tables, medical. London: H.M.S.O., 1971.
- Registrar General's Statistical review of England and Wales for the year 1970.
Part I Tables, medical. London: H.M.S.O., 1972.
- Registrar General's Statistical review of England and Wales for the years 1973-1974. Part I Tables, medical. London: H.M.S.O., 1974.

Report on hospital in-patient enquiry for the years 1949, 1957 - 1967.

'Historical' tables. London: H.M.S.O., 1972.

Report on hospital in-patient enquiry for the year 1970. Part I tables.

London: H.M.S.O., 1972.

Rigler, L. G., Borman, C. N. and Noble, J. F. (1941) Gallstone obstruction; pathogenesis and roentgen manifestations, JAMA, 117, 1753 - 1759.

Rigler, L. G. and Lipschultz, O. (1940) Roentgenologic findings in acute obstruction of colon, with particular reference to acute volvulus of sigmoid, Radiology, 35, 534 - 543.

Rigler, L. G. and Pogue, W. L. (1965) Roentgen signs of intestinal necrosis, Am J Roentgenol Radium Ther Nucl Med, 94, 402 - 409.

Robertson, J. A., Eddy, W. A. and Vosseler, A. J. (1958) Spontaneous perforation of the caecum without mechanical obstruction, Am J Surg, 96, 448 - 452.

Roseman, D. M., Kowlessar, O. D. and Sleisenger, M.H. (1960) Pulmonary manifestations of pancreatitis, N Engl J Med, 263, 294 - 296.

Salleh, H. B. M. and Balasegaram, M. (1974) Treatment of acute cholecystitis by routine urgent operation, Br J Surg, 61, 705 - 708.

Samuel, E. (1957) The gas-filled appendix, Br J Radiol, 30, 27 - 30.

Sanders, R. (1967) Incidence of perforated duodenal and gastric ulcer in Oxford, Gut, 8, 58 - 63.

Sands, W. W. (1955) Extraluminal localized gas vesicles; an aid in the diagnosis of abdominal abscesses from plain roentgenograms, Am J Roentgenol Radium Ther Nucl Med, 74, 195 - 203.

Schatzki, R. (1939) The roentgenologic appearance of intussuscepted tumours of the colon, with and without barium examination, Am J. Roentgenol Radium Ther, 41, 549 - 563.

Schorr, S. (1963) Small-intestinal intramural air, Radiology, 81, 285 - 287.

Schultz, E. H., Jr. (1963) Aids to diagnosis of acute pancreatitis by roentgenologic study, Am J Roentgenol Radium Ther Nucl Med, 89, 825 - 836.

Schwartz, S. and Nadelhaft, J. (1957) Simulation of colonic obstruction at the splenic flexure by pancreatitis: roentgen features, Am J Roentgenol Radium Ther Nucl Med, 78, 607 - 616.

Schwarz, G. (1911) Die Erkennung der tieferen Dünndarmstenose mittels des Röntgenverfahrens, Wien Klin Wochenschr, 24, 1386 - 1390.

Scott, J. R., Miller, W. T., Urso, M. and Stadalnik, R. C. (1971) Acute mesenteric infarction, Am J Roentgenol Radium Ther Nucl Med, 113, 269 - 279.

Shaw, R. E. (1965) Appendix calculi and acute appendicitis, Br J Surg, 52, 451 - 459.

Shaw, R. S. and Rutledge, R. H. (1957) Superior mesenteric artery embolectomy in the treatment of massive mesenteric infarction, New Engl J Med, 257, 595.

Shepherd, J. A. Surgery of the acute abdomen, 2nd ed. Edinburgh: Livingstone, 1968(a), 247.

Shepherd, J. A. Surgery of the acute abdomen, 2nd ed. Edinburgh: Livingstone, 1968(b), 195 - 216.

Shepherd, J. A. Surgery of the acute abdomen, 2nd ed. Edinburgh: Livingstone, 1968(c), 1 - 36.

Shepherd, J. A. Surgery of the acute abdomen, 2nd ed. Edinburgh: Livingstone, 1968(d), 245 - 300.

Social Services Statistics (Health and Personal) for England.

Department of Health and Social Security, 1974, London: H.M.S.O. 1974.

Soteropoulos, C. and Gilmore, J. H. (1958) Roentgen diagnosis of acute appendicitis, Radiology, 71, 246 - 256.

Stein, G. N., Kalser, M. H., Sarian, N. N. and Finkelstein, A. (1959) An evaluation of the roentgen changes in acute pancreatitis: correlation with clinical findings, Gastroenterology, 36, 354 - 361.

Steinert, R., Hareide, I. and Christiansen, T. (1943) Roentgenologic examination of acute appendicitis, Acta Radiol (Stockh), 24, 13 - 37.

Stephens, F. O. (1962) The syndrome of intestinal pseudo-obstruction, Br Med J, 1, 1248 - 1250.

Stephens, F. O. (1966) Intestinal colic caused by food, Gut, 7, 581 - 582.

Stuart, C. (1956) Acute pancreatitis; preliminary investigation of a new radiodiagnostic sign, J Fac Radiologists, 8, 50 - 58.

- Sweetman, W. R. and Wise, R. A. (1959) Acute perforated tuberculous enteritis: surgical treatment, Ann Surg, 149, 143 - 148.
- Swinburn, J. (1976) Personal communication.
- Thomas, D. (1968) Acute small bowel obstruction, Aust NZ J Surg, 37, 302 - 309.
- Trapnell, J. E. (1974) Acute pancreatitis, Br J Hosp Med, 12, 193 - 203.
- Vick, R. M. (1932) Statistics of acute intestinal obstruction, Br Med J, 2, 546 - 548.
- Wangensteen, O. H. Intestinal obstructions: physiological, pathological and clinical considerations, 3rd ed. Springfield (Ill.): Charles C. Thomas, 1955.
- Ward-McQuaid, J. N. (1950) Intestinal obstruction due to food, Br Med J, 1, 1106 - 1109.
- Wastell, C. Chronic duodenal ulcer. London: Butterworth, 1972.
- Waye, J. D. and Lithgow, C. (1967) Small bowel perforation in regional enteritis, Gastroenterology, 53, 625 - 629.
- Webster, C. U. and Weir, R. D. (1958) Perforated peptic ulcer in North-East Scotland, Scott Med J, 3, 288 - 296.
- Wellwood, J. M., Wilson, A. N. and Hopkinson, B. R. (1971) Gastrografen as an aid to the diagnosis of perforated peptic ulcer, Br J Surg, 58, 245 - 249.
- Whitehead, T. J. (1971) Multiple analyses and their use in the investigation of patients, Adv Clin Chem, 14, 389 - 407.
- Wilkie, D. P. D. (1931) Observations on mortality in acute appendicular disease, Br Med J, 1, 253 - 255.
- Williams, J. L. (1964) Obstruction of the small intestine, Radiol Clin North Am, 2, 21 - 31.
- Wilson, D. H. (1976) Personal communication.
- Wilson, P. D., Horrocks, J. C., Lyndon, P. J., Yeung, C. K., Page, R. E. and de Dombal, F. T. (1975) Simplified computer-aided diagnosis of acute abdominal pain, Br Med J, 2, 73 - 75.
- Wiot, J. F. and Felson, B. (1961) Gas in the portal venous system, Am J Roentgenol Radium Ther Nucl Med, 86, 920 - 929.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Michael Sumerling in Edinburgh and Mr. F. G. Smiddy in Leeds for the time and effort they devoted to supervising the preparation of this thesis. The cooperation and tolerance of the Radiology Departments at the General Infirmary at Leeds, St. James's University Hospital, Leeds and the Bradford Group of Hospitals is acknowledged, in particular the help of Dr. Nigel Barraclough, now Consultant Radiologist at Burton on Trent.

The typing of this thesis was carried out by Mrs. Elaine Nutter, the production of the illustrations by Mr. Peter Harrison and help with the references by Miss Daphne Roberts to all of whom my grateful thanks are given.

Lastly the author would wish to recognise the stimulation and guidance provided during his surgical training by Professor Sir James Fraser in Southampton and Professor John Goligher in Leeds.

APPENDIX I

The Plain X-Ray in the Acute Abdomen

Grade of participant

The purpose of this survey is to compare the expertise of surgeons and radiologists when reporting the plain x-ray in the acute abdomen.

Although each individual completing the proforma will be informed of his 'score' should he so wish, under no circumstances will the results of the survey be published under the participants' own names.

Instructions

1. Please insert medical grade in top left hand corner, e.g. consultant radiologist, senior registrar surgeon, senior registrar radiologist, etc.
2. Please answer the questions in the space provided. No time limit is placed on the survey.
3. Marks will be deducted for a wrong answer, but no marks will be lost for a space left blank.
4. Although spaces for naming three or four radiological features are provided, this does not necessarily mean three or four features are present.
5. Normal x-rays are included in the survey, and if you consider an x-ray normal please state so.

The Plain X-ray in the Acute Abdomen

No. 1 History: 12 year old female with 48 hour history of central and right iliac fossa pain.

Examination: Diffuse lower abdominal tenderness and guarding.

List the radiological features shown:

- 1.
- 2.
- 3.
- 4.

What is the likely diagnosis?

.....

No. 2 History: 48 year old male with a five hour history of severe central abdominal pain of sudden onset. No relevant past history.

Examination: Board-like rigidity throughout the abdomen.

List the radiological features shown:

- 1.
- 2.
- 3.
- 4.

No. 3 History: 63 year old male admitted to Casualty collapsed and complaining of severe left side abdominal pain.

What is the diagnosis?

.....

No. 4 History: 55 year old female with a 36 hour history of epigastric and right upper quadrant pain with nausea and vomiting. P.H. of indigestion.

Examination: Pyrexia. Right upper quadrant tenderness and marked guarding over whole of upper abdomen.

What radiological features are seen?

- 1.
- 2.
- 3.
- 4.

No. 5 History: 18 year old girl with repeated episodes of colicky abdominal pain in the past. Present attack of 24 hours colicky, central abdominal pain and vomiting. P.H. of laparotomy 6 years previously for "stoppage of the bowel".

Examination: Melanin spots on buccal mucosa. Tenderness in R.I.F. with suggestion of a lower abdominal mass.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 6 History: 48 year old female with sudden onset of generalised abdominal pain and vomiting.

Examination: Distended abdomen with tenderness in the R.I.F. and high-pitched bowel sounds.

Name the radiological features:

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 7 History: 62 year old female with history of central abdominal pain and vomiting for 18 hours.

Examination: Poor peripheral circulation with irregular low volume pulse, and systolic B.P. of 80 m.m.Hg. Abdominal signs of generalised peritonitis.

What radiological features are seen?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 8 History: 45 year old male with epigastric pain of sudden onset with profuse vomiting.

Examination: Generalised abdominal tenderness and rebound tenderness. No bowel sounds. W.C.C. 15,000. S. amylase 900 somozzic units.

What radiological features are seen on the 3 x-rays consistent with the above history?

X-Ray A:

X-Ray B:

X-Ray C:

No. 9 History: 40 year old female with 12 hour history of severe epigastric pain and vomiting. P.H. of many similar previous attacks.

What radiological features are seen?

- 1.
- 2.
- 3.
- 4.

No. 10 History: 60 year old male with 12 hour history of colicky central abdominal pain and vomiting. P.H. of ulcer surgery.

Examination: Old right paramedian scar. Slight abdominal distention. No tenderness. High-pitched bowel sounds.

What radiological features are shown?

- 1.
- 2.
- 3.

No. 11 History: 80 year old male with colicky left sided abdominal pain and constipation.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 12 History: 75 year old female with sudden onset of constant lower abdominal pain. P.H. of intermittent constipation and diarrhoea.

Examination: Gross abdominal distention.

What is the diagnosis?

.....

No. 13 History: 30 year old female with persistent blood stained diarrhoea and lower abdominal pain.

Examination: Abdominal distention with generalised tenderness and rebound.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 14 History: 80 year old female complaining of severe, lower abdominal pain, vomiting and constipation.

Examination: Diffuse lower abdominal tenderness and distended abdomen.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 15 History: 55 year old male complaining of severe indigestion, heartburn and bile-stained vomiting for many years.

Examination: Anaemic. Epigastric tenderness.

What is the diagnosis?

.....

No. 16 History: 38 year old male re-admitted three weeks following routine cholecystectomy complaining of shivering attacks and constant abdominal pain.

1. What x-ray features are shown?

- 1.
- 2.
- 3.

2. What is the diagnosis?

.....

3. What x-rays would you ask for?

- 1.
- 2.

No. 17 History: 17 year old young man admitted after a gang fight with stab wounds of the upper abdomen.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 18 History: 42 year old female complaining of right sided abdominal pain and swelling for three months.

Examination: Anaemic. Large right sided abdominal mass.

What radiological features are seen on this plain x-ray?

- 1.
- 2.
- 3.
- 4.

No. 19 History: 36 year old male complaining of severe, colicky right loin pain of 2 hours duration.

What are the opacities seen?

- 1.
- 2.
- 3.

No. 20 History: 49 year old female complaining of persistent left sided abdominal pain, nausea, anorexia, dysuria and frequency.

Examination: Left sided abdominal tenderness and guarding with abdominal mass.

What radiological features are shown?

- 1.
- 2.

What is the diagnosis?

.....

No. 21 History: 40 year old male complaining of lower abdominal pain and frothing while urinating.

What is shown on the x-rays?

- 1.
- 2.

What x-ray examinations would you ask for?

- 1.
- 2.

No. 22 History: 65 year old male complaining of non specific abdominal pain. P.H. of operation for bowel stoppage.

Examination: Lower abdominal mass.

What is the diagnosis?

.....

No. 23 History: 70 year old female admitted to medical wards with lethargy, tiredness and weight loss. Recent onset of abdominal pain.

What is shown on the x-rays?

.....

No. 24 History: 63 year old female complaining of intermittent left iliac fossa pain and constipation.

No. 24 Examination: No abnormal physical signs.
(cont.)

What radiological features are shown?

- 1.
- 2.
- 3.

What is the diagnosis?

.....

No. 25 History: 50 year old female complaining of lumbar back pain radiating round both loins. Recent weight loss and lethargy. P.H. of hysterectomy and simple mastectomy.

Examination: Jaundiced, cachexic with distended abdomen.

What radiological features are shown?

- 1.
- 2.
- 3.

What is the diagnosis?

.....

What surgical procedure has been performed?

.....

No. 26 History: 50 year old Egyptian complaining of lower abdominal pain, dysuria, frequency and haematuria. P.H. of pulmonary tuberculosis.

What is shown?

.....

What is the differential diagnosis?

- 1.
- 2.
- 3.

No. 27 History: 53 year old Scottish Highlander complaining of right upper quadrant abdominal pain, indigestion, nausea and fat intolerance.

What is shown?

.....

What is the differential diagnosis?

- 1.
- 2.
- 3.
- 4.

No. 28 History: 20 year old male involved in a road traffic accident.

What injuries have been sustained?

- 1.
- 2.
- 3.

No. 29 History: 22 year old female, known to be pregnant, complaining of right iliac fossa and right loin pain.

What is the diagnosis?

.....

No. 30 History: 40 year old female complaining of pain radiating from the lumbar region to the lower part of the abdomen.

Examination: Tender in right and left loins.

What radiological features are shown?

- 1.
- 2.
- 3.

No. 31 History: 36 year old female complaining of central abdominal pain and vomiting. P.H. of cholecystectomy and hysterectomy.

Define the radiological features on films A and B in detail and give your conclusion.

- A
- 1.
 - 2.
 - 3.

- B
- 1.
 - 2.
 - 3.

Conclusion:

No. 32 What is shown on this x-ray?

.....

No. 33 History: 24 year old boy complaining of R.I.F. pain for 24 hours.

Examination: Tender in right iliac fossa.

What radiological features are shown?

- 1.
- 2.
- 3.

No. 34 History: 12 hour history of central abdominal pain, nausea and vomiting.

Examination: Epigastric tenderness and guarding.

What radiological features are seen?

- 1.
- 2.
- 3.

No. 35 History: 49 year old male with 10 year history of indigestion complaining of upper abdominal pain and vomiting.

What radiological features are shown?

- 1.
- 2.
- 3.

What is the diagnosis?

.....

No. 36 History: 9 year old girl complaining of 2 months intermittent lower abdominal pain.

Examination: Tenderness in right lower abdomen with suggestion of fullness.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 37 History: 65 year old female complaining of sudden onset of lower abdominal pain.

Examination: Lower abdominal tenderness and guarding.

What radiological features are seen?

- 1.
- 2.
- 3.

No. 38 History: 68 year old female complaining of 2 year history of intermittent colicky L.I.F. pain with constipation. 12 hour history of severe lower abdominal pain.

Examination: Abdominal signs of peritonitis.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

No. 39 History: 75 year old ex-lord mayor of Bradford complaining of colicky central abdominal pain and vomiting. P.H. of multiple laparotomies.

Examination: Scarred abdomen with no other physical signs.

What is seen?

- 1.
- 2.
- 3.
- 4.

No. 40 History: 84 year old female complaining of colicky abdominal pain and vomiting.

Examination: Distended abdomen with obstructive bowel sounds.

What radiological features are seen?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

What other radiological features might you expect to see?

- 1.
- 2.

No. 41 History: 24 year old building labourer injured in a fall from a building.

What is the diagnosis?

.....

No. 42 What radiological feature is seen on this x-ray of a 70 year old male complaining of dysuria and frequency?

.....

No. 43 History: 46 year old male complaining of lower abdominal pain and haematuria.

Examination: No physical signs.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 44 History: 60 year old male complaining of left sided abdominal pain and constipation.

Examination: Distended abdomen. Tender in right and left iliac fossae.
PR - NAD.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 45 History: 68 year old female complaining of two weeks history of lower abdominal pain, nausea and constipation.

Examination: Tender in right iliac fossa with slight rebound.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 46 History: 4 day old neonate admitted from home (home delivery) because of poor condition and history of passing no bowel motion.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

What is the diagnosis?

.....

No. 47 History: 11 day old child admitted because of failure to thrive with persistent vomiting and crying.

Examination: Ill. Distended silent abdomen.

What radiological features are seen on the x-ray?

- 1.
- 2.
- 3.
- 4.

What is the likely diagnosis in a child of this age?

.....

No. 48 History: 50 year old female complaining of upper abdominal pain.

Examination: Tender in whole of right side of abdomen.

Name the radiological signs.

- 1.
- 2.
- 3.
- 4.

No. 49 History: 18 year old male complaining of colicky abdominal pain and vomiting 6 days after small bowel resection for Meckel's diverticulitis.

What radiological features are shown?

- 1.
- 2.
- 3.

What is the diagnosis?

.....

No. 50 History: 73 year old male complaining of colicky lower abdominal pain right side, left side together with constipation.

What radiological features are shown?

- 1.
- 2.
- 3.
- 4.

APPENDIX II

PUBLICATIONS



JOURNAL OF THE ROYAL COLLEGE OF SURGEONS OF EDINBURGH

VOL. 15: 1970.

Radiology in acute appendicitis

David Jenkins¹ and Peter Lee¹

The commonest emergency admitted to a general surgical ward in this country is acute appendicitis. When the diagnosis is doubtful the surgeon on duty will frequently include plain X-rays (erect and supine) of the abdomen as part of his preoperative assessment. The evaluation of these films initially falls to the resident surgical staff in charge of the urgent admissions, and a specialist interpretation, radiological or surgical, is not always available.

This study is an analysis of the radiological findings in 114 consecutive cases of suspected acute appendicitis during the time the authors were house surgeons. Its purpose is to appraise the value of emergency radiology as interpreted by us and performed under the waiting-day conditions that obtained when our unit was on duty to receive emergencies.

Method

During a period of 6 months 114 emergency cases considered by the house surgeons to be suffering from acute appendicitis were admitted to Sir John Bruce's unit in The Royal Infirmary of Edinburgh. The diagnosis was based on the classical textbook descriptions of acute appendicitis, and included consideration of a WBC count and microscopic examination of the urine. Erect and supine X-rays of each patient were performed routinely by the duty radiographer in the Accident and Emergency Department.

At the end of the 6-month period the X-rays were re-examined jointly by the authors without direct reference to the eventual outcome of the case. Their findings and conclusions were then correlated with the ultimate diagnosis in each patient. Only those with a "positive" pathological report

were accepted as genuine cases of acute appendicitis, but no attempt was made to differentiate between grades of severity. "Subacute appendicitis" and "chronic appendicitis" were not regarded as positive reports for the purpose of this trial.

Radiological signs of acute appendicitis

Nine radiological signs are described in the literature (Brooks, 1965) as being of value in diagnosis of acute appendicitis:

- (1) Localised ileus in the right lower quadrant of the abdomen shown by loops of distended bowel in that area or air/fluid levels in the terminal ileum, caecum or ascending colon.
- (2) An increase in soft tissue density in the right lower quadrant, represented by blurring of the sacroiliac joint on the right side and indicating soft tissue swelling or abscess formation.
- (3) Obliteration or widening of the right "flank stripe" (i.e. the radiotranslucent curve lateral to the peritoneal line which is produced by the adipose tissue separating peritoneum and transversus abdominis muscle).
- (4) The presence of radiopaque concretions (appendicoliths) in the classical appendiceal positions (Fig. 1).
- (5) Blurring or obliteration of the distal third of the right psoas outline, caused by an overlying inflamed or oedematous appendix or by muscle spasm.
- (6) The presence of gas in the appendix (Samuel, 1957).
- (7) Left convex lumbar scoliosis, indicating reflex guarding of the contents on the right side of the abdomen.
- (8) Presence of extraluminal gas in the right lower quadrant as a result of perforation of the viscus.
- (9) Deformity of the caecal outline, a distended caecal gas shadow distorted by the presence of oedematous tissue or an abscess.

¹ Department of Clinical Surgery, University of Edinburgh.

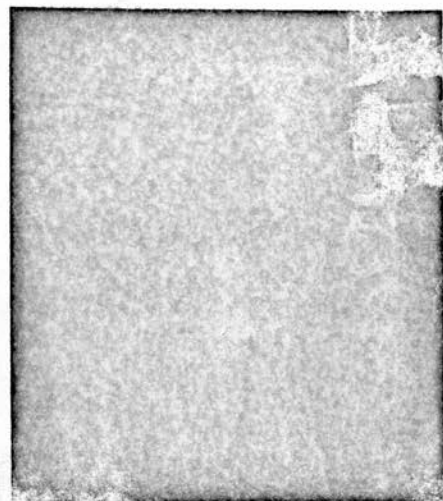


FIG. 1

A typical appendicolith. Also present are: localised ileus, obliteration of distal third right psoas outline, increased soft tissue density and left lumbar convex scoliosis.

Results

In 114 patients a diagnosis of acute appendicitis was made preoperatively; 94 were submitted to surgery and appendectomy was carried out. In the remainder a policy of observation or further investigation was decided upon.

Of the 94 appendices removed, 74

TABLE 1

FINAL DIAGNOSIS OF CASES NOT
SUBMITTED TO EMERGENCY
APPENDICETOMY

Diagnosis	Cases
Undiagnosed abdominal pain	9
Ureteric colic	3
Right pyelonephritis	2
Gastroenteritis	2
Acute diverticulitis	2
Acute cholecystitis	1
Premenstrual pain	1

were reported by the pathologist as cases of acute appendicitis and 20 as normal.

An analysis of the 20 cases regarded by the general practitioners and house surgeons as suggestive of appendicitis but not submitted to emergency surgery is given in Table 1. Table 2 shows the correct diagnosis in the 20 patients who had a normal appendix at operation. The radiological findings in the 74 cases of confirmed appendicitis are shown in Table 3, and are compared with similar findings in the other two groups.

TABLE 2

DIAGNOSIS IN CASES WITH
NORMAL PATHOLOGY REPORTS

Diagnosis	Cases
No other pathology	5
Simple ovarian cyst	4
Meckel's diverticulum	2
Pyosalpinx	2
Crohn's disease (ileocaecal)	1
Mesenteric adenitis	2
Perforated duodenal ulcer	1
Adhesions	1
Carcinoma of caecum	1
Basal chest infection (manifest later)	1

Discussion

Statistical conclusions cannot be derived from the figures quoted because of the small numbers involved. It is of interest, however, that 35% of patients referred as cases of acute appendicitis were misdiagnosed, although in only 15% was abdominal pathology not found.

In this series the most common radiological signs on plain abdominal X-rays in acute appendicitis are, in decreasing order of frequency: localised ileus in the right iliac fossa (present in 53% of cases, three-quarters of which showed fluid levels), an increased soft

TABLE 3

RADIOLOGICAL FINDINGS IN PATIENT GROUPS

Radiological sign	Groups of patients		
	Acute appendicitis	Normal appendix removed	No emergency surgery
Local ileus (with fluid level)	29 (39%)	8 (40%)	6 (30%)
Local ileus (without fluid level)	31 (42%)	9 (45%)	7 (35%)
Soft tissue density	16 (22%)	2 (10%)	2 (10%)
Flank stripe	3 (4%)	3 (15%)	0 (0%)
Appendicolith	1 (1%)	0 (0%)	0 (0%)
Psoas obliteration	6 (8%)	4 (20%)	1 (5%)
Appendicular gas	0 (0%)	0 (0%)	0 (0%)
Lumbar scoliosis	10 (14%)	0 (0%)	3 (15%)
Extra-luminal gas	1 (1%)	0 (0%)	0 (0%)
Deformed caecum	3 (4%)	1 (5%)	0 (0%)

tissue density and a sympathetic lumbar scoliosis. With the possible exception of the infrequently occurring appendicolith no one sign is pathognomic of appendicular pathology. Brady and Carrol (1957) reported the association between appendicitis and the presence of an appendicolith. When radiological ileus along with one of the other signs listed was used as a diagnostic aid, it was found that only 24 of the 74 cases of confirmed appendicitis demonstrated the combination, as did 4 of the remaining 40. It is of interest that the correct diagnoses in the 4 "false positives" were a ruptured ovarian cyst, a leaking carcinoma of caecum, a low-lying distended and inflamed gallbladder and one case of undiagnosed abdominal pain. Thus, in the presence of two radiological signs suggesting acute appendicitis, one of which was localised ileus, only one patient was without pathology in the right iliac fossa.

On the basis of these results we feel there is no indication for routine abdominal radiology in cases of appendicitis although in ill patients, when the

diagnosis is in doubt, the procedure may help in deciding whether or not to operate. It is possible that more sophisticated radiology with standard exposures, rigidly controlled positioning of the patient and comparable magnifications might yield a greater number of positive signs. In a busy Accident and Emergency Unit, however, such perfection is rarely practical.

Summary

- (1) An analysis is presented of the abdominal radiological findings in 114 consecutive cases, referred to hospital as acute appendicitis.
- (2) There are no pathognomic radiological signs of acute appendicitis, although X-rays are of value in determining the presence of right abdominal pathology requiring surgical intervention.

Acknowledgments

We are grateful to Sir John Bruce and his staff for the stimulus to undertake this investigation and to Dr. Eric Samuel, Director of the Department of Diagnostic Radiology

JENKINS AND LEE

in the Royal Infirmary of Edinburgh, for access to his files.

REFERENCES

BRADY, B. M. and CARROL, D. S. (1957).
Radiology, **68**, 648.

BROOKS, D. W. and KILLEN, D. A. (1965).
Surgery, **57**, 377.

SAMUEL, E. (1957). *Br. J. Radiol.*, **30**, 27.

SOTEROPOULOS, C. and GILMORE, J. H. (1958). *Radiology*, **71**, 246. X

STEINART, R., HAREIDE, I. and CHRISTIANSEN, T. (1943). *Acta radiol.*, **24**, 13.

- no contrasts.
- mucous
- normal appendix

REPRINTED FROM



The British Journal of Surgery

JOHN WRIGHT & SONS LIMITED BRISTOL

ERRATUM

Table I page 764 should be titled:

Radiological signs in 74 cases of
Acute Appendicitis

The plain X-ray in the acute abdomen: a surgeon's evaluation

P. W. R. LEE*

SUMMARY

The plain abdominal X-rays of 277 patients suffering from five acute abdominal conditions were reviewed and specific radiological features found to occur in not less than 48 per cent of the cases. In a second series of 249 patients admitted to hospital with an acute abdomen due to all types of disease, the plain abdominal X-rays were helpful in 42 per cent of cases. A questionnaire of 50 plain abdominal X-rays was answered by surgeons and radiologists of varying clinical experience, the scores of the senior radiologists being higher. It is suggested that plain abdominal X-rays should become a routine investigation in the acute abdomen, and should be reported by senior radiologists at the time of the investigation.

ALTHOUGH radiologists are skilful in the interpretation of the acute abdominal X-ray, and are familiar with the literature on this subject in the radiological journals, it is usually the resident surgical officer who must make his own assessment of the plain X-ray and act accordingly. This study is an attempt by one such surgeon to evaluate the place of the plain X-ray in the acute abdomen by considering three questions:

1. Which radiological signs are present in the plain X-ray in the acute abdomen? What is their incidence?
2. Should plain abdominal X-rays be routinely performed in the acute abdomen?
3. Who should report the acute abdominal X-ray?

1. Which radiological signs are present in the plain X-ray of the acute abdomen? What is their incidence?

Patients and methods

Five acute abdominal conditions were considered: (a) acute appendicitis, (b) acute cholecystitis, (c) acute pancreatitis, (d) perforated duodenal ulcer and (e) intestinal obstruction. A review of the literature produced a series of radiological signs which are said to occur in the plain abdominal X-rays of each of these five diseases. These signs are listed in Tables I-VI.

During the period September 1971 to June 1975 the author studied the patients who were admitted to the Leeds area group of hospitals complaining of acute abdominal pain. Only the patients who were personally examined and assessed are included. A postero-anterior chest X-ray together with erect and supine abdominal X-rays were performed on each patient. A record was made of the patient's final diagnosis and in this way a collection of patients suffering from the five acute abdominal conditions listed above was compiled. The X-rays were reviewed retrospectively for the specific radiological features noted in Tables I-VI.

Results

Two hundred and seventy-seven patients were examined, the detailed incidence of the specific radiological signs being shown in Tables I-VI. In acute appendicitis one or more radiological signs were found in 48 per cent of the 65 cases; in acute cholecystitis one or more signs occurred in 64 per cent of 64 patients. In acute pancreatitis 60 per cent of the 34 had abnormal X-rays, and in perforated duodenal ulcer abnormal X-rays were present in 60 per cent. In 42 patients suffering from small bowel obstruction diagnostic features were present in all but one, and in 25 patients with large bowel obstruction due to malignant disease classic diagnostic features were present in all the cases.

Discussion

The results show that, in a retrospective review, specific radiological features can be identified in approximately 50 per cent of patients who suffer from an acute abdominal catastrophe due to the five causes listed above. In acute appendicitis the sign most frequently identified was that of air-fluid levels or gaseous distension of either the caecum or the adjacent small bowel, interpreted as a local adynamic ileus. This confirms the findings of Brooks and Killen (1965).

In acute cholecystitis the most frequent radiological finding was radio-opaque calculi, which occurred in 25 per cent of the cases studied, a much higher incidence than that recorded by McCort (1973). In addition, the high incidence of a visible soft tissue mass found in this series in acute cholecystitis is in agreement with the findings of Salleh and Balasegaram (1974).

The most reliable diagnostic sign in acute pancreatitis is the presence of the sentinel loop sign, which was first described by Grollman et al. (1950), in which one or more loops of jejunum are seen in the left upper quadrant of the abdomen. Of secondary importance is evidence of a localized ileus in the stomach or duodenum. The colon cut-off sign described by Price in 1956 in which the large bowel is dilated up to either the hepatic or splenic flexure was found in one-fifth of the cases.

In 60 per cent of the cases of perforated duodenal ulcer a pneumoperitoneum was identified. This is much lower than the incidence of 70-80 per cent quoted in the standard surgical textbooks (Thompson, 1972; Rains and Ritchie, 1975).

* Department of Surgery, The General Infirmary, Leeds

Table I: RADIOLOGICAL SIGNS IN 65 CASES OF ACUTE APPENDICITIS

Radiological sign	No. of cases	%
1. Local ileus	29	39
2. Soft tissue density	16	22
3. Flank stripe obliteration	3	4
4. Appendicolith	1	1
5. Psoas obliteration	6	8
6. Convex lumbar scoliosis	10	14

Table II: RADIOLOGICAL SIGNS IN 64 CASES OF ACUTE CHOLECYSTITIS

Radiological sign	No. of cases	%
1. Calculi	16	25
2. Soft tissue mass	13	20
3. Local ileus	3	10
4. Free fluid	6	5
5. Basal chest changes	6	10

Table III: RADIOLOGICAL SIGNS IN 34 CASES OF ACUTE PANCREATITIS

Radiological sign	No. of cases	%
1. Duodenal ileus	5	14
2. Gastric ileus	10	28
3. Sentinel loop	13	38
4. Generalized ileus	0	0
5. Stuart's sign	1	2.5
6. Colon cut-off sign	6	21
7. Pancreatic calcification	0	0
8. Calculi	0	0
9. Chest X-ray: elevated diaphragm		
Right	1	21
Left	5	
10. Chest X-ray: plate atelectasis	0	0
11. Chest X-ray: pleural effusion		
Right	2	14
Left	3	

Table IV: RADIOLOGICAL SIGNS IN 34 CASES OF PERFORATED DUODENAL ULCER

Radiological sign	No. of cases	%
1. Gas under diaphragm: single	9	28
2. Gas under diaphragm: air-fluid level	9	28
3. Gas under liver	3	9
4. Gas on lateral X-ray	0	0
5. Free fluid around stomach	3	9
6. Free fluid around liver	0	0
7. Free fluid around bowel	3	9
8. Free fluid in flank	2	6
9. Free fluid in pelvis	3	9
10. Ulcer shown as niche	1	3
11. Ulcer shown by distorted duodenum	0	0
12. Paralytic ileus	3	9
13. Chest X-ray: atelectasis	0	0
14. Chest X-ray: elevated diaphragm	3	9
15. Chest X-ray: pleural effusion	0	0

Table V: RADIOLOGICAL SIGNS IN 42 CASES OF SMALL BOWEL OBSTRUCTION

Radiological sign	No. of cases	%
1. Distended small bowel	39	92
2. Gas-fluid levels	41	97
3. Transverse loops	14	36
4. Hoop loops	22	55
5. 'String of beads'	4	10
6. Gas streaking	2	5
7. Soft tissue density	—	0
8. 'Coffee bean' sign	—	0
9. Colon empty of gas and faeces	—	0
10. Fixed loop sign	1	2.5

In small bowel obstruction all but one patient had some of the radiological features of gut obstruction. The most frequent signs observed were gaseous distension of the bowel on the supine X-ray and the gas-fluid levels seen on the erect X-ray. The 'string of beads' sign described by Frimann-Dahl in 1960, caused by bubbles of air trapped under the distended valvulae conniventes of the small bowel, was found in only 10 per cent. The 'coffee bean' sign of Mellins and Rigler (1954) and the pseudo-tumour of Frimann-Dahl (1944), described by these authors as the specific signs of a strangulated loop of bowel, were not identified in this series.

Gaseous distension and air-fluid levels were identified in all the 25 patients suffering from large bowel obstruction due to carcinoma. The most frequent configuration was a distended caecum with a competent ileocaecal valve, and distension of the small bowel proximal to the competent valve. Only rarely were the caecum and large bowel dilated without evidence of small bowel obstruction. These findings confirm those of Love (1973).

2. Should plain abdominal X-rays be routinely performed in the acute abdomen?

Patients and methods

From January to April 1971 all the patients admitted to The General Infirmary, Leeds, with an acute abdominal condition were routinely X-rayed. A postero-anterior chest and erect and supine abdominal X-rays were performed. In this period only 6 patients, who were thought to be pregnant, together with 2 patients who were too ill to undergo an X-ray examination were omitted from the study. The history and clinical examination of each patient were recorded on a standard *pro forma*, together with the casualty officer's provisional diagnosis. Each patient was followed up during his hospital admission and the final diagnosis recorded, either from that admission or from subsequent outpatient investigation.

Retrospectively, each series of X-rays was reported by a radiologist who was provided with the history sheet and provisional diagnosis. The X-ray report was compared with the final clinical diagnosis and each X-ray was then classified by the author into one of the following groups: (a) of no help in diagnosis, (b) diagnostic, (c) of help in diagnosis and (d) wrong diagnosis.

Results

A total of 249 consecutive cases were examined and there were 47 different final clinical diagnoses. The cases in which a definite diagnosis was not reached, which formed the largest single group (14 per cent), were classified as 'non-specific abdominal pain'. A comparison between the radiologist's assessment and the final clinical diagnosis is shown in Table VII; 57 per cent of the X-rays were considered to be unhelpful and 42 per cent were considered to be of help in diagnosis of which 18 per cent were diagnostic. The radiologist's report was considered to infer an incorrect diagnosis in 2 cases.

Discussion

Many arguments can be marshalled against the routine use of X-rays in the acute abdomen. It could be said that a negative yield rate, defined as an unhelpful X-ray, of 57 per cent is too high. Secondly, it can be argued that routine exposure to irradiation is unethical. Lastly, it could be said that routine radiology is expensive and that the financial and administrative difficulties of providing a 24-hour radiological cover are insurmountable.

However, it is the author's opinion that the routine use of abdominal X-rays is justified on the following grounds. A positive yield of 42 per cent from a 'single' investigation is, in fact, high when compared with the yield rate of other investigations; for example, routine biochemical investigation has a positive yield rate of only 18 per cent (Whitehead, 1971). No ethical problem exists because all patients suspected of pregnancy are excluded. The material cost and irradiation exposure of the three X-rays performed, using equipment already installed, is very low when compared with the number of X-rays performed, for example, during a barium meal or an intravenous pyelogram. In almost all hospitals in this country in which acute medicine is undertaken, arrangements are already in existence for 24-hour radiographer cover.

For the purpose of this survey an X-ray was considered 'helpful' only in the presence of positive radiological signs. In many cases, however, the presence of a normal X-ray or one which did not show a specific radiological sign was equally helpful to the clinician. Inclusion of such 'negative help' only supports the argument in favour of the performance of routine acute abdominal X-rays.

3. Who should report the acute abdominal X-ray?

Materials and methods

A questionnaire was prepared in which the participant was asked to report 50 plain abdominal X-rays. All but 2 of these X-rays showed some specific radiological feature of the acute abdomen. A short case history was provided with each X-ray and the participant was asked to list the radiological features seen and then make a final diagnosis. The questionnaire was submitted to radiologists and surgeons of varying clinical experience from the grade of casualty officer to consultant. Five radiologists and five surgeons were included in each grade and the average score of each group was calculated as a percentage of the maximum score possible.

Results

The average score of each group of participants is shown in Table VIII. The highest score of 95 per cent was obtained by the consultant radiologists, compared with a score of 70 per cent by the consultant surgeons. The senior registrar radiologists' score was 88 per cent and that of the senior surgical registrars 81 per cent. The lowest scores were those of the registrar radiologists, surgical registrars and the casualty officers, being 60, 61 and 57 per cent respectively.

Table VI: RADIOLOGICAL SIGNS IN 25 CASES OF LARGE BOWEL OBSTRUCTION DUE TO CARCINOMA

Radiological sign	No. of cases	%
1. Distended caecum and large bowel with competent ileocaecal valve	2	8
2. Distended caecum and large bowel with secondary obstruction of small bowel due to competent ileocaecal valve	17	67
3. Distended large bowel with no caecal distension and incompetent ileocaecal valve	6	25

Table VII: RADIOLOGISTS' ASSESSMENT COMPARED WITH FINAL DIAGNOSIS IN 249 CASES OF ACUTE ABDOMEN

Assessment	No. of cases	%
No help in diagnosis	143	57
Diagnostic	59	24
Of help in diagnosis	45	18
Wrong diagnosis	2	1

Table VIII: AVERAGE SCORE OF RADIOLOGISTS AND SURGEONS IN ACUTE ABDOMINAL X-RAY QUESTIONNAIRE

Grade	Average % score of live participants*	
	Radiologist	Surgeon
Consultant	95	70
Senior registrar	88	81
Registrar	60	61
Casualty officer	—	57

* Maximum score 100%.

Discussion

The scores obtained by the various groups are of considerable interest, as some would have anticipated both the consultant and senior registrar radiologists to have scored better than any other group. Senior registrar surgeons scored better than their consultants, possibly because the majority of their day to day work is involved with the assessment of the acute abdomen. However, the greatest difference in the scores was found between the senior doctors and the junior registrars and casualty officers. It is apparent from the answers to the questionnaire that the degree of accuracy with which the junior registrars assessed the plain X-rays is unacceptably low. This, therefore, suggests that if the plain X-ray is to be of maximum value as a routine investigation its reporting must be carried out by a senior radiologist at the time of its performance.

Conclusions

The following answers to the questions asked in the study were obtained:

1. Specific radiological features can be found in not less than 48 per cent of the plain X-rays in patients suffering from one of five acute abdominal diseases studied.

2. In a consecutive series of 249 acute abdominal admissions the radiology report was considered positively helpful in diagnosis in 42 per cent of the cases. It is the author's opinion that the plain X-ray

of the acute abdomen should become a routine investigation.

3. The plain abdominal X-rays must be reported, at the time of the investigation, by a senior radiologist if maximum benefit is to be obtained.

Acknowledgements

My thanks are due to the consultant surgeons of the Leeds area who allowed their patients to be studied and to the radiologists and radiographers who cooperated in the taking and reporting of the films. In particular, I would like to thank Dr N. Barraclough for his radiological help and Mr F. G. Smiddy for his constant advice and encouragement.

References

- BROOKS D. W. and KILLEN D. A. (1965) Roentgenographic findings in acute appendicitis. *Surgery* **57**, 377-384.
- FRIMANN-DAHL J. (1944) Strangulating obstructions of the small bowel with special reference to cases with poor roentgen findings. *Acta Radiol.* **25**, 480-492.
- FRIMANN-DAHL J. (1960) *Roentgen Examinations in Acute Abdominal Diseases*, 2nd ed. Springfield, Ill., Thomas, pp. 34-333.
- GROLLMAN A. J., GOODMAN S. and FINE A. (1950) Localised paralytic ileus, an early roentgen sign in acute pancreatitis. *Surg. Gynecol. Obstet.* **113**, 490-496.
- LOVE L. (1973) Large bowel obstruction. *Semin. Roentgenol.* **8**, 229-232.
- MCCORT T. J. (1973) Acute hepato-biliary disease. *Semin. Roentgenol.* **8**, 389-403.
- MELLINS H. Z. and RIGLER L. G. (1954) The roentgen findings in strangulating obstruction of the small intestine. *Am. J. Roentgenol.* **71**, 404-415.
- PRICE C. W. R. (1956) The colon cut-off sign in acute pancreatitis. *Med. J. Aust.* **1**, 313-314.
- RAINS A. J. H. and RITCHIE H. D. (1975) *Bailey and Love's Short Practice of Surgery*, 16th ed. London, Lewis, p. 775.
- SALLEH H. M. and BALASEGARAM M. (1974) Treatment of acute cholecystitis by routine urgent operation. *Br. J. Surg.* **61**, 705-708.
- THOMPSON J. C. (1972) *Davis-Christopher's Textbook of Surgery*, 10th ed. Philadelphia, Saunders, p. 835.
- WHITEHEAD T. J. (1971) Multiple analyses and their use in the investigation of patients. *Adv. Clin. Chem.* **14**, 389-407.

PNEUMOPERITONEUM IN PERFORATED DUODENAL
ULCER DISEASE - A FURTHER LOOK

P W R Lee¹

P D M Costen¹

D H Wilson¹

¹Accident and Emergency Department, The General Infirmary at
Leeds, Leeds 1, Yorkshire

(This paper is prepared for submission)

The incidence of radiological pneumoperitoneum in 70 cases of perforated duodenal ulcer disease was 60%. It is suggested that the apparent decrease in incidence of pneumoperitoneum is related to the quicker hospitalisation of the ill patient.

The incidence of radiologically detectable pneumoperitoneum in perforated duodenal ulcer disease is variously quoted as 70-80% in the classical surgical textbooks (Rains and Capper, 1971; Thompson, 1972; Desmond, 1969) although clinically its incidence would now appear to be much lower. The present study was designed to determine prospectively the incidence of radiological pneumoperitoneum. A possible explanation for this lower incidence of pneumoperitoneum is advanced.

Materials and Methods

A routine chest x-ray, together with erect and supine abdominal x-rays were performed in every case of suspected perforated duodenal ulcer admitted to the General Infirmary at Leeds, during the period 1971-1973. The erect radiographs were taken after the patient had maintained the upright posture for at least three minutes. Lateral decubitus films were not taken routinely but were used in two cases when the patients were judged too ill to sit erect. The diagnosis of perforated duodenal ulcer was accepted only if confirmed at subsequent laparotomy. A careful record of the time of onset of the abdominal pain was obtained from each patient, this being taken

as the time of perforation. The time of admission of each patient to the Accident and Emergency Department was recorded and all radiographs were performed following this in the Casualty X-Ray Department. It was possible from these data to determine the time between perforation and x-ray. The radiographs obtained were reviewed retrospectively for the presence of pneumoperitoneum.

Results

Seventy confirmed cases of perforated duodenal ulcer were studied, of which 53 were males and 17 females. Pneumoperitoneum was present in 42 cases (60%) and absent in 28 cases (40%). The times from perforation to x-ray in all cases were divided into the time intervals shown in Table 1 and matched against whether pneumoperitoneum was present or absent.

Discussion

It would appear from the above results that the incidence of pneumoperitoneum has fallen from the previously accepted level of 70-80% to 60%, a figure in agreement with that of 61% recently quoted (Wellwood et al, 1971). The design of this study was intended to exclude other factors which would contribute to an apparent fall in incidence; thus an effort was made to ensure an adequate period in the upright position before erect x-rays were taken and on two occasions x-rays judged to be of inadequate quality were

excluded from the series. A study is at present being conducted by the authors to determine whether or not the incidence of radiological pneumoperitoneum is altered by routine inclusion of a lateral decubitus x-ray, the early results of which indicate that the incidence will not be greatly affected, even with the impractical suggestion that the patient should maintain the left lateral position for some 30 minutes before ^{the} x-ray is taken (Miller et al, 1971).

The results equating the length of perforation time to the presence or absence of pneumoperitoneum showed that there was no difference for a perforation time under eight hours; however, when the perforation time was of relatively long standing (ie greater than eight hours duration), there was a marked increase in the presence of pneumoperitoneum. This fact could explain the fall in incidence of pneumoperitoneum. With modern trends towards quicker hospitalisation of the ill patient, fewer patients are seen with a prolonged history of perforation, the majority (in our series 70%) being in hospital within eight hours of the onset of symptoms.

REFERENCES

Desmond A M (1969) in "Maingots Abdominal Operations"
5th Edition p 354. London: Butterworths.

Miller R E, Nelson, S W (1971) Am J Roentgenol 112 574.

Rains A J, Harding, Capper W M (1971)
"Bailey and Love's Short Practise of Surgery",
15th Edition p 769. London: Lewis.

Thompson J C (1972) "Davis-Christopher's Textbook of Surgery",
10th Edition p 835. Philadelphia: Saunders.

Wellwood J M, Wilson A N, Hopkinson B R (1971), Br J Surg 58 245.

TABLE 1

INCIDENCE OF PNEUMOPERITONEUM COMPARED TO PERFORATION TIME

Time from perforation to x-ray (hours)	Less than 2 hours	2-4 hours	4-8 hours	Greater than 8 hours
Pneumoperitoneum present (number of cases)	7	9	9	17
Pneumoperitoneum absent (number of cases)	6	9	9	4